Vol. XV. — No. 1. January 1933.

BULLETIN
OF THE
INTERNATIONAL RAILWAY CONGRESS
ASSOCIATION
(ENGLISH EDITION)

SPECIAL ACCOUNTS

summing up the reports on the questions for discussion at the twelfth session of the International Railway Congress Association (Cairo, 1933).

SECTION I. — Way and works.

[625.162 & 656.254]

QUESTION I:

The protection of level crossings in view of modern developments in road traffic,

by A. MISZKE,
Special Reporter.

The object of the present report is to summarise the three following reports :

Report No. 1 (America, Great Britain, its Dominions and Colonies China, Japan and Egypt), by Mr. A. NEWLANDS (1);

Report No. 2 (Belgium, Spain, France, Italy, Holland, Portugal and their Colonies, Denmark, Finland, Luxemburg, Norway, Sweden and Switzerland), by Mr. BATICLE (2);

Report No. 3 (all other countries), by Mr. A. MISZKE (3).

(1) See *Bulletin of the Railway Congress*, April 1932, p. 329.

(2) See *Bulletin of the Railway Congress*, August 1932, p. 1641.

(3) See *Bulletin of the Railway Congress*, July 1932, p. 1283.

GENERAL OUTLINE.

Legislative regulations and conventions.

There are legal requirements concerning the protection of level crossings in every country where such crossings are numerous. Such legislation differs considerably from one country to another and takes into account the actual development of road motor traffic in various ways.

In *Great Britain*, according to the law of 1845, the level crossing gates must be large enough to close in the railway when they are shut across the railway track, and the Ministry of Transport can order the railways to keep the gates closed across the railway track except when

trains require to pass. Trains crossing a main road near a station ought to reduce their speed to 6 k. (4 miles) an hour. Mr. Newlands points out however that this speed limit is rarely observed.

The regulations of the Ministry of Transport of 1928 stipulate that level crossing gates must be so built that they can be shut alternatively across the railway and across the road.

The gates are fitted with discs and lamps, or with a signal which may be either a fixed or operable one. In this latter case the signal must be interlocked with the gates and indicate to the driver if the gates are shut across the road or not.

Mr. Newlands remarks (p. 352) that in practice the usual position of the gates is across the public road, except in the case of light railways in which case they can be shut across the railways and be opened and shut by the train staff. In all such cases the railway traffic is small and the road traffic considerable.

There are no other laws in England taking the motor traffic into account.

In *Canada* in 1922, 1929 and 1930 laws and prescriptions were formulated concerning the disc marked « stop » and at night the red lamps to be placed by crossing keepers on level crossings across main roads, the installation of warning signs in the form of a St. Andrew's cross marked « Railway Crossing », and lastly automatic signalling on level crossings.

In *Australia,* in 1926, it was decreed that the « Railway Board » could order any automatic signals considered necessary to be set up in addition to the « stop » warning notices. According to an amendment made in 1928, vehicles must reduce their speed to 15 miles an hour 100 yards from the level crossing.

In the *United States of America* the protection of level crossings is dealt with by the State Commission of the local authorities. Consequently the regulations vary from one State to another.

In the State of New York detailed prescriptions regulate the installation and maintenance of automatic signals on level crossings (Mr. Newlands' report, p. 347).

According to Mr. Newlands' report, in the States of New Jersey, Vermont, and some others, there are no regulations or laws of any kind and the protection of each level crossing is left to the discretion of the railway company concerned. In the States of New York and Delaware the road users must keep a sharp look out when approaching a level crossing to safeguard themselves against accident and if they do not take these precautions they are guilty of contributory negligence. The State of Delaware goes even further and requires all drivers of road vehicles to stop before running onto a level crossing.

In *Brazil, according* to the Decree of the 7 September 1922, there must be gates at level crossings in order to close the road when trains are passing. The Government can authorise the railway to dispense with the use of gates or crossing keepers if the road or rail traffic is small. Drivers must whistle when approaching the crossing. According to the Decree of the 27 July 1928, dealing with the international road motor traffic, warning notices, of a type similar to those fixed by the Convention of 1926, must be put up on the road 150 to 250 m. (164 to 273 yards) from the level crossing.

In *Columbia*, the law decrees that there shall be keepers at every level crossing. It is, however, proposed to amend this law and only make it obligatory to have keepers near large centres of population.

In *Ceylon* and the *Federated Malay States,* the regulations make provision for the gates to shut across the railway track, in the same way as in Great Britain.

In *Italy*, the law of the 27 November 1919 and the Decree of the 7 November 1920 authorise the Administration of the State Railways to leave the crossings permanently open without it being necessary to have keepers at level crossings on

main and secondary lines; there is also a Royal Decree of the 4 September 1925 relative to level crossings without keepers.

In *Denmark*, the law of the 1 February 1930 and the decree of the 16 March 1931 lay down the rules for the installation and location of the crossing signs at level crossings without keepers.

In *Spain*, the law of the 26 November 1877 which required level crossings to be kept closed against the road and only opened for the passage of vehicles or pedestrians was amended by the Royal Decree of the 22 June 1928, which authorised the railway companies to dispense with crossing keepers in certain cases for certain categories of crossings, and replace them by a signalling system.

In *Finland*, the order of the Ministry of Communications of the 2 April 1929 and the law of the 3 May 1927 lay down the regulations as to warning signals and protective apparatus, to the cutting down of trees and the removal of other obstacles to good visibility at a distance of at least 50 m. (55 yards) in the neighbourhood of level crossings.

In *Luxemburg*, the law on railways of the 17 December 1859 states that gates must be set up at all level crossings and these must always be kept shut in accordance therewith. The Ministerial Decree of the 25 July 1871 deals with the question of the construction of over- and under-bridges as well as the lighting and closing of level crossings.

In *Portugal*, the regulations of 1868 make it necessary to have keepers at all level crossings.

In *Switzerland*, the conditions governing the classification and the working of level crossings are the subject of the Federal Ordinance of the 7 May 1929.

In *France*, the law of the 15 July 1845 lays down that the railways must be fenced in on both sides throughout the system and that gates must be set up at all level crossings. The law of the 26 March 1897 made an exception to this rule by authorising the Ministry of Public Works to dispense the railways from setting up gates at certain level crossings. Finally a ministerial decision of the 12 July 1926 allowed the railways to dispense with the services of keepers at certain level crossings in order to test signalling systems which could take the place of keepers.

In *Germany*, the regulations concerning level crossings are found in : 1. the *Eisenbahn-Bau und Betriebsordnung* (E. B. B. O.); 2. the *Technische Vereinbarungen über den Bau und den Betrieb der Hauptbahnen und Nebenbahnen;* and 3. the *Grundzüge für den Bau und den Betrieb der Lokalbahnen.* The last edition of the *Bau und Betriebsordnung* of the 11 July 1928 recommends the use of crosses as warning signs instead of the notices formerly used.

In *Poland* at the present time, the *Principal regulations for the construction and operation of standard gauge public railways*, ratified the 2 December 1931, are in force. Recently a special Commission has drawn up regulations for the protection of level crossings, taking the requirements of present-day motor traffic into account; these regulations tend to limit the employment of keepers replacing them, visibility permitting, by notice boards or automatic optical signals. These regulations were ratified by the beginning of 1932. The details of these regulations will be given below when the different questions are dealt with. The regulations of the U. I. C. (International Railway Union) are to be applied within a period of two years.

In *Czechoslovakia*, it is proposed to modify the legislation on this matter; the reason for such modification is the considerable development of road traffic. A new law on the railways is also to be formulated which will take the ever increasing road traffic into consideration.

In the case of lines of local interest the existing regulations have been modified

by a new law by which gates are only installed on the express demand of the authorities.

Moreover, a special decree of the Ministry of Railways has to be published, as regards safety at level crossings in connection with the present development of road traffic.

In *Jugoslavia,* the question of level crossings is regulated by the law on the railways, of 1930.

A ministerial decree published in 1929 has brought the regulations of the U. I. C. into force, in the matter of the warning signs where the roads and rails cross each other, taking the development of the motor traffic into account, and because of this law administrative regulations have been published concerning :

1. indicators and warning signs at unprotected level crossings;
2. visibility at level crossings, and
3. the abolition of gates.

The other countries appear, from the replies received, to have only very general laws which date in *Norway* from 1848, in *Holland* from 1913, 1926 and 1930, and in *Switzerland* from 1924. Finally the replies received from *Belgium, China, Egypt, Japan* and *Uruguay* make no mention of any laws or regulations dealing with level crossings. There are, however, in those countries which have no general laws and regulations, special regulations concerning level crossings, published by the railways, which are very up-to-date and take the development of the road traffic into account; such regulations are found for example in *South Africa* and *India.*

Regulations concerning road traffic at level crossings.

Apart from the obvious necessity of stopping at a certain distance from the level crossing when a train is approaching, a question of less importance from the point of view of this report, it is interesting to determine from the replies received in what countries vehicles are required to stop before a level crossing, and in what countries they are required to slow down, at what distance from the crossing and to what extent.

In the following countries vehicles are required to stop before reaching an unprotected level crossing : in *Switzerland,* 10 m. (11 yards) away; in *Georgia (U. S. A.),* when the visibility is poor, at a distance of 50 yards from the nearest rail; in Quebec (*Canada*) if the level crossing is not fitted with automatic signalling; and in *New Zealand,* at most level crossings where the traffic is considerable.

Vehicles are required to slow down : in *Australia,* to 15 miles an hour when 100 yards from the crossing; in *Belgium* to 10 km. (6.2 miles) an hour; in *Georgia (U. S. A.)* to 6 miles when the visibility is good; in *Holland* to 20 km. (12.4 miles) between the warning signal and the level crossing; in *Poland* to 10 km. (6.2 miles) an hour in the case of motors and 6 km. (3.7 miles) an hour for other vehicles, but a proposal to make it obligatory for all vehicles to stop before level crossings is under consideration; in *Virginia (U. S. A.)* vehicles have to slow down to 8 miles an hour 50 yards away from the level crossing.

In *Finland* the speed must be such that the driver can stop the vehicle immediately if necessary; in *Germany* vehicles only have to slow down if the road surface or the road conditions makes this precaution necessary, or if there is very heavy traffic. In *Switzerland,* after the vehicles have stopped, they must only cross the track at walking speed.

Positions of the warning signs on the road.

Triangular signs of the agreed pattern of the International Convention of 1926 are set up in the following countries,

their distance from the level crossing being given in brackets : in *Germany* [200 m. (656 feet)]; in *Belgium* [250 m. (820 feet)], they are always installed if the traffic consists of at least 10 motors per day, although such signs are not obligatory by law; in *Brazil* [150 to 250 m. (492 to 820 feet)]; in *Bulgaria* (150 to 250 m.) and in *Denmark* (150 to 250 m.) at the more important level crossings; in Finland they are obligatory; in France there are few such signs in use; [250 m. (820 feet)], in the *Dutch East Indies;* in *Italy* they are being installed at all level crossings; in *Norway;* in *Holland* (200 to 250 m.); in *Portugal* (250 m.) at level crossings with keepers; in *Poland* (150 to 250 m.) on all roads with high-speed motor traffic; in *Sweden* according to the decree of 1931 signs of this type must be set up at all level crossings without keepers; in *Switzerland;* in *Czechoslovakia* (150 to 250 m.); in *Jugoslavia* (150 to 250 m.) on all the State roads.

Warning signs of other types are used in the following countries :

In *South Africa,* a warning sign in the form of a St. Andrew's cross 100 yards from the level crossing; in the *United States of America* a warning sign is set up 600 feet from the crossing, but according to the American Railway Engineering Association it should be set up 200 to 450 feet, and at last 100 feet in the towns. In *Great Britain* there are warning notices at unprotected level crossings (usually on light railways) at least 50 yards from the crossing; in *India* there is a conventional sign 300 feet away; in *Japan;* in *Luxemburg*; in *New South Wales* (Australia) 300 feet from the crossing there is a notice consisting of a white disc with a black cross and under it a red triangle fitted with cat's eye reflectors at open level crossings where there are no gates when the visibility in the neighbourhood is poor, and also at level crossings with gates when local conditions make it advisable; in *New Zealand,* where conditions are exceptional and no gates are used, a St. Andrew's cross marked « Railway Crossing » is placed on the road 440 feet from the railway. In addition a notice with the inscription « Railway - Look out for Engine » is put up 9 feet from the track.

Participation of the public authorities in the establishment and upkeep costs of the different methods of protection or in replacing level crossings by bridges or subways, should the increase in the road traffic make this necessary.

In *Germany,* the railway regulations merely provide for the charge to be borne by the railway or the road authorities according as to whether the protection of the crossing is made necessary by the railway or the road traffic. Should there be any dispute, the decision rests with the Ministry of Communications.

In *Canada,* since 1909 there has been a « Railway Grade Crossing Fund » created by an Act of Parliament to which a sum of $ 200 000 is allotted every year so that it can « assist by means of constructional work in assuring the protection, safety and convenience of the public as far as the crossing of roads and railways on the level is concerned ». The money allotted has to be spent entirely on constructional work, not on maintenance or working, and must not exceed 20 % of the total cost nor $ 5 000 per level crossing. The money cannot be used for more than three level crossings in one municipality during the course of a single year, nor more than once for a given level crossing. In 1919, the proportional limit was increased to 25 %, not exceeding $ 15 000 for one level crossing with a maximum of 6 level crossings in one municipality. In 1926 the proportion was again increased to 40 % with a maximum of $ 25 000 for a single level crossing. In 1928, a new amendment was passed making it possible for the fund to contribute to the expense of suppressing level crossings built since the 1 April 1909 and not

later than 1 April 1929. At the same time the allocation per level crossing was increased to $ 100 000 and to 40 % of the total cost.

On the 31 December 1927 the work subsidised by this fund had cost $ 6 812 716, made up as follows : 14 % subsidised from the fund, 40 % paid out by the municipalities from their own funds, and 46 % paid by the railways.

In order to illustrate the character of the work done, I will quote some of the figures given in Mr. Newlands' report (page 376). The level crossings concerned numbered 1299 and the work included among other things : 208 electric bells 374 electric bells and wig-wag signals 125 gates, 50 flashing light signals, 53 overhead bridges, 107 subways. In 202 cases the road was deviated, and this made it possible to close 155 level crossings and to stop the traffic over 84 level crossings. In 1930, a further 23 level crossings were closed, 30 level crossings suppressed, and 51 electric bells with wig-wag signals were installed.

In the *United States of America,* from the publications of the American Railway Engineering Association it appears that in spite of the diversity in the administration of the roads which are controlled by 150 000 organisations, there is a certain tendency to recognise that it is only just that the Treasury of the Federation and those of the individual States should share in the cost of replacing level crossings by bridges and subways, as well as in the cost of improving and perfecting their protection. At the present time, they share such expenses by 50 % on the average, their share varying in the different States from 10 to 100 %. On their side the railways have proposed the following division of the cost of replacing level crossings by bridges or subways : 50 % to be paid by the General Treasury and 50 % by the State itself and the railway administration according to local conditions.

In *Poland,* according to an ordinance dating from the 2 July 1924, when an existing level crossing is reconstructed, the cost is borne by the railway administration or the road administration, depending upon which one of them decided such reconstruction was necessary.

In *Czechoslovakia,* the cost of installations and buildings on the road near railways or actually on the railway made necessary by the development of the road motor traffic is borne by the railway and the public authorities concerned in proportion to the benefit each of them obtains thereby.

The other railway administrations do not report any special regulations nor methods of dealing with this problem.

The road warning sign is usually set up at the cost of the road authorities or motor associations.

Protection of level crossings.

A. Level crossing keepers.

Level crossings at which there are keepers but no gates are not found to any great extend except in the *United States, New Zealand* and *Turkey;* in these countries this is done for economic reasons.

In *Germany,* there are very few level crossings of this type. In *Czechoslovakia,* level crossings without gates have keepers only in exceptional cases on lines where the maximum speed is from 40 to 50 km. (25 to 31 miles) an hour, the road traffic very heavy and the visibility poor. In *Poland,* keepers are only employed at level crossings without gates in the event of failure of the automatic signalling.

In the *United States of America,* keepers are only employed at level crossings in the towns themselves. In 1927 there were 7 554 level crossings with keepers but no gates, out of a total of 236 283, i. e. 3 % and the number of level crossings protected in this way decreases from year to year.

The statistics of accidents quoted by Mr. Newlands (pages 338-339) show that many accidents have occurred in *Canada* at this type of level crossing with the result that keepers are still employed in such cases. Nonetheless the number of such level crossings in Canada was not mentioned.

In *New Zealand,* gates are not used at level crossings. In towns where the traffic is heavy watchmen are used to carry notice boards with the word « Stop » painted in black letters on a yellow background.

In the United States of America the question of using automatic gates controlled by the trains is under consideration. From the list of level crossings rebuilt with the assistance of the « Railway Grade Crossing Fund » quoted by Mr. Newlands on page 374 of his report, up to 1930 only three automatic gates are seen to have been installed in Canada. The information received does not give any other precise details on this subject.

In Germany and Finland it is thought advisable to erect a warning sign at level crossings with keepers and gates, in addition to the ordinary triangular sign located 200 to 250 m. (656 to 820 feet) before the level crossing. In Germany in the immediate vicinity of the level crossing warning signs of a special form, a sort of half cross (cf. fig. 1, page 1206 of our report) are put up. The German State Railway Administration thinks that signs of this type make the driver of a vehicle appreciate how near the crossing is, especially on curves, and states that since such signs have been put up there has been a decrease in the number of gates damaged by motors running into them.

In *Finland* a single warning sign in the form of a St. Andrew's cross is put up 26 feet from the railway, for single track, double track and also for several lines. This cross must be visible to the road users at least 50 feet away, when motor traffic is prohibited, and 164 feet in other cases. At level crossings where there is much traffic these signs are fitted with lights such as winking lights, in order to make them more visible.

The gates are fitted with fixed signs during the day and red lamps at night — in Finland, France, Great Britain, Norway, Sweden, Czechoslovakia, Turkey and part of Jugoslavia. Red lamps are not used — in Bulgaria, Spain, Luxemburg, Switzerland and Poland, where the latest regulations merely require level crossings with keepers where the traffic is heavy to be lighted in a general fashion. In the same way the German Railways no longer use red lamps since the introduction of another system consisting in painting the gates in red and white stripes. These gates which are well-lighted, are visible from a good distance.

The time the gates must be closed before the arrival of a train is :

2 minutes in Poland — in the case of certain level crossings this time can be extended or decreased;

3 minutes in Holland and Switzerland;

3 and 5 minutes in France;

5 minutes in Denmark, Italy, Luxemburg, Portugal, Czechoslovakia, Turkey and Jugoslavia;

5 to 10 minutes in Spain;

10 minutes in Norway.

They must be closed when the train leaves the station preceding the level crossing in Bulgaria. In Germany no precise time is fixed. The replies of the other railway administrations gave no information on this point.

Warning given at the level crossing of the approach of a train.

Warning of the approach of a train is given at the level crossings by means of a bell or by telephone from the preceding station in Bulgaria, Spain, Italy, Luxemburg, Norway, Holland, Switzerland, Czechoslovakia and Jugoslavia, and from the previous signal box in Germa-

ny. In Poland and at those level crossings in Czechoslovakia and Jugoslavia where there is neither bell nor telephone, the keeper has to depend upon the timetable.

In Turkey drivers of trains which are late have to give a long whistle as a warning signal 1.2 miles away from the level crossing; usually the keeper works according to the timetables. On the Smyrna-Cassaba Railway the gates automatically shut on the approach of a train.

In Portugal and France automatic alarm bells have been fitted at certain level crossings which are worked by the train when it is 5 km. (3.1 miles) away in Portugal and 1 800 m. (1.1 miles) away in the case of the French State Railways where warning of the approach of a train is given to all crossing keepers on the main lines, but is not obligatory on secondary lines if the speed does not exceed 40 km. (25 miles) an hour. On the other French Railways automatic bell installations are included in a general programme which has been approved by ministerial decree. The idea is to provide a warning at all level crossings where the period of visibility is less than 20 seconds and the product of the average number of road vehicles and of trains in one direction is more than or equal to 600.

Mr. Baticle's report gives some very interesting details on this point (p. 1662).

Gates operated from a distance.

In Germany, Denmark, Luxemburg, Holland and Switzerland the keeper must be able to see the whole of the level crossing. In Spain, France, Finland and Italy, Norway, Poland, Sweden, Czechoslovakia and Jugoslavia this is not obligatory. The other countries consulted gave no information ou this point.

Distant operated gates are usually kept open and closed when a train passes, or else they are normally kept closed and opened for the benefit of the road users on request. The first method is found in Spain, Finland, Italy and Holland. In Belgium, and in France both methods are used. In France a certain number of such level crossings are fitted with apparatus giving warning of the approach of the trains, such apparatus being fitted at the place from which the gates are worked. In France there is a tendency to make distant operation of level crossing gates general.

In practice the following distances between the keeper's post and the level crossing are found : in Germany about 300 m. (984 feet) and in the case of crossings where the traffic is small on rural roads 600 to 700 m. (1 968 to 2 296 feet); in Bulgaria 800 m. (2 624 feet); in Czechoslovakia 1 500 m. (4 920 feet); in Turkey 200 m. (656 feet) (most of such level crossings are near stations); in Jugoslavia 1 500 m. (4 920 feet). According to the regulations in force this distance must not exceed 800 m. (2 624 feet) in Denmark, and 800 to 1 000 m. (2 624 to 3 280 feet) in Poland. Four gates at the most (Jugoslavia) are worked by the same transmission.

B. Automatic signalling of trains at level crossings.

Automatic signals which warn the public when a train is approaching or passing are most widely used in the *United States of America* where in 1927, there were 15 213 level crossings without keepers at which such automatic appliances were fitted.

In *Australia,* signals with flashing lights worked by track circuits and wig-wags of a revolving type (fig. 10, p. 358 of Mr. Newlands' report) are used.

In *Canada* in some cases flashing lights of the type used in the United States are employed, but the Railway Commissioners have adopted the wig-wag as the standard type of signal for Canada.

In *Italy,* 71 sets of apparatus of this type are now in service. They have been

installed at level crossings where many accidents had occurred, or else at crossings on very important roads with heavy traffic. This apparatus are of the following types : wig-wag, Guzzani type, Riccardi type, Barduzzi type and they all have the following general qualities :

— visual signal clearly visible during the daytime by means of semaphores, discs, etc.,

— luminous signals during the day and the night,

— audible signals.

Automatic signals are used in *Sweden* in all cases where the visibility is poor. The number of arrangements fitted is fairly considerable. For example on the State Railways there are 282 signals replacing the former gates, 125 are fitted at old level crossings without keepers, and 7 at new level crossings. They are of the automatic winking Gasaccumulator (A. G. A.) type. The railways which have used such apparatus appear quite satisfied with them.

In *Switzerland* the higher authorities have descreed that gates can be replaced by signs with flashing lights, formed of a triangular plate with three red lights and a bell or warning whistle.

In *Brazil,* 5 groups of audible and luminous signals are to be put up at level crossings without keepers of 2nd-class roads across main line double track railways. These apparatus consist of red flashing lights and an alarum gong. Trains approaching the level crossing work an electric pedal installed 1 km. (0.6 mile) from the crossing.

In *New Zealand* at most level crossings of any importance the existing means of protection is now being replaced by audible signals (bells) and visual signs, wig-wag and flashing lights automatically worked by means of track circuits, but flashing lights, very similar to those used in America, must be used exclusively in the future to protect level crossings.

In *Japan,* flashing light signals are used, as well as bells, and lamps, either in conjunction with gates, or alone; these signals are worked by means of track circuits.

Automatic appliances are being installed for trial purposes in South America, Belgium (wig-wags and Signum), in Ceylon, Finland (A. G. A.), France (on the Nord Railway), in Norway, Poland and Jugoslavia; it is likewise proposed to put up such signals in Denmark at level crossings without keepers when the visibility is poor.

Mr. Baticle's report gives the opinions of the administrations consulted on the question asked them by the reporter, namely the measures they consider likely to improve safety at level crossings, taking the modern development of the road traffic into account. both in the case of level crossings with keepers and those without.

Their opinions on the subject of automatic signals are summarised as follows :

Belgium. — According to the Belgian National Railway Company « it appears that the best way of improving safety while crossing would consist in providing at the level crossings signals automatically announcing the arrival of the trains, but these signals have not yet been perfected and are very costly. They require constant supervision and very careful, i. e., very expensive maintenance ».

Denmark. — The Danish State Railways are of the opinion that the best step to improve safety at level crossings, if this visibility is not sufficient is to supplement it by means of visual signals for announcing the approach of trains.

Spain. — According to the Madrid-Saragossa-Alicante Railways, the most desirable steps to be taken are the following :

. . . . . .

« 2. Level crossings without keepers. — When the traffic is very great, signals on the road and warning of the approach of a train. »

Finland. — 1. In the case of level crossings with keepers, with very heavy traffic, the best gates are those which are provided with optical signals and powerful bells... These conditions are especially important if, when the visibility on the railway is bad, the gates are equipped with devices automatically announcing the approach of a train.

2. In the case of level crossings without keepers, with nevertheless important traffic, optical and audible signals entirely or partially automatic announcing the approach of the trains are recommended.

France. — In the case of level crossings without gates, the road users have themselves to look after their own safety. If visibility is insufficient, the arrival of the train must be made known by special means as, for example, the locomotive whistle. The distance at which the train should call attention to its presence in this way should be such that when its speed is taken into account, it will not require more than 12 seconds to reach the level crossing.

Italy. — As regards level crossings without keepers, the use of warning apparatus should be made general.

Norway. — The Norwegian State Railways consider the most desirable arrangement to be that which consists of automatic winking signals with red and white lights. In towns, however, it is preferable to retain the level crossing keepers.

Switzerland. — In the case of the Swiss Federal Railways the requirements of the Ordinance of the 7 May 1929 are the most likely to assure safety at level crossings, whether this safety be obtained by gates or by optical and acoustic signalling, by means of signals worked by employees of the railway, or automatically by the train, or by a simple indication of the existence of the crossing given by means of warning signals.

Article 4 *b* (1) of the Ordinance of the 7 May 1929 lays down that: when there is optical and acoustic signalling, the gates are replaced by winking light signals formed by a triangular plate with 3 red lights and a warning bell or hooter.

Although this shows that the majority of the railways consulted by Mr. Baticle favour automatic signalling, Mr. Baticle agrees with the opinion of the French Railways and gives the preference to gates, completed in certain cases by automatic warning signals worked by the train on approaching the level crossing. Mr. Baticle expresses his opinion as follows :

Whenever the railway traffic is considerable or the visibility poor, the stop signal to be given to the public is in principle the level crossing gate. The working of an appliance operated by an employee will always be more certain than that of an automatic appliance no matter how prefected this latter may be. The keeper closes his gates when he is warned of the approach of a train by telephone or by the warning signal, the pedal of which will be for example 2 000 m. (1.24 miles) away from the crossing.

On the same subject among the countries included in our report, in Germany the opinion is held that automatically operated appliances can replace completely both gates and keepers. If well designed and well-maintained apparatus is used, the cases of failure to act are no more frequent than those of mistakes committed by the keeper. As regard the road traffic, automatic signalling has the advantage over gates in that the traffic is not held up longer than necessary.

In Poland the opinion is that such appliances when well-designed and manufactured and well maintained can definitely replace keepers at level crossings. The new Polish laws on the safety of traffic at level crossings adequately take this system of signalling and protection into account.

We can quote the following passage from Mr. Newlands' report on this subject : « In the United States of America the American Railway Engineering Association has arrived at the conclusion that the automatic visual signal of the wig-

wag or flashing type gives the most efficient protection. »

The distance at which the train should be from the level crossing when the automatic apparatus begins to function has not yet been fixed in a uniform manner by the different railways.

In *Germany, Italy* and *Poland,* it depends upon the maximum speed of the trains at the crossing and should be such that the warning signal begins to function 30 seconds before the train reaches the level crossing when this is of the usual width.

In *Switzerland,* the regulations lay down 30 to 45 seconds.

In *Brazil,* the automatic apparatus is placed 1 km. (0.6 mile) from the level crossing and in New South Wales (Australia) 4 000 feet.

In the *United States of America,* the signals usually function 20 seconds before the fastest trains reach the level crossing. It is thought to be a drawback if they work too long beforehand because of the temptation to « cut across ».

The Polish and Swiss regulations require the automatic apparatus to function until the last wagon of the train has cleared the crossing.

Type of automatic apparatus used, number and arrangement of the lights, number of flashes.

In *Germany,* only one type is used. When the crossing is clear the signal shows a white light, which flashes 40 times a minute. When a train approaches the white light is covered by a coloured glass and the signal shows a red light which flashes twice as quickly. The faster flashing makes even colourblind road users able to recognise the signal. When the light does not flash the apparatus is obviously out of order and the road users must take the usual precautions when crossing. In order to prevent a signal which has gone out during the night being overlooked by the drivers it is surrounded by a red and white square border. This border as well as the warning cross above it is so made as to reflect the lights from the head lamps of the motor cars.

In *Canada,* the Railway Commissioners have adopted the wig-wag signal as the standard type for Canada and have issued the following orders on the subject :

Post. — The signal must be placed upon a post of suitable structural material. If the post is made of wood it must be of sound timber not less than 8 by 8 inches and 18 feet long, and shall be firmly set in the ground to a depth of four feet. If it is made of iron or steel it shall not be less than 4 inches in diameter, shall extend at least twelve feet above the ground, and shall be firmly bolted to a concrete or other foundation constructed below the frost line.

Bell. — A bell which shall emit a clear, loud volume of sound under all weather conditions must be used.

Wig-wags. — Wig-wags shall be of the three-aspect type, and when in operation must shew a clear bright light.

In the *United States of America,* it seems that the Mississippi is the boundary line between the two types used : east of this river flashing light signals predominate, while west of it wig-wags are the most popular type. The lamps are placed 6 to 9 feet above the road with a distance of 2 1/2 feet from centre to centre. The flashes occur at the rate of about 30 per minute and the rays of light show at least 300 feet away in broad daylight; the spread of the beam is about 3° on each side of the centre line. The lenses are 6 to 8 inches in diameter. As for the wig-wags, the disc moves 2 ft. 6 in. between the extreme points of its travel and the rate is about 30 to 40 double movements per minute.

In *Switzerland,* as was said above the type of signal with flashing lights formed

of a triangular plate with three red lights flashing 80 times a minute have been prescribed.

The visual signals are lit by electricity or acetylene gas if some distance from a supply of electricity.

The form of automatic signal used differs considerably from one country to another. Many of the railway administrations consider that level crossings protected by means of automatic signals should also be fitted with fixed signs, for example those in the form of a St. Andrew's cross, either as a separate sign as in Poland, or by fitting them on the automatic signals as in Germany, in the type adopted by the American Railway Engineering Association, or in the type adopted in Canada.

In *Switzerland,* level crossings fitted with signals giving warning of the approach of trains are not fitted with fixed signs which are used at level crossings where the approach of the trains is not signalled.

In *Germany* and *Poland,* when the apparatus goes wrong a keeper is sent to the crossing.

In several cases in Germany, for trial purposes, control apparatus has been installed which indicates at the neighbouring station when the apparatus is out of order. It is not proposed, however, to extend the use of such control apparatus everywhere as any definite failure is easily discovered by the road users.

In Poland, when temporary keepers cannot be sent to the level crossing, the locomotive must give the warning signals by whistling or by its bell. The same steps are taken when in the case of a double track line the trains are worked temporarily in both directions on one track alone.

Fixed signs at level crossings without keepers.

The signs most usually employed as a fixed sign at level crossings where no keeper is employed is a cross mounted on a post 2.50 to 3 m. (8 ft. 2 7/16 to 9 ft. 10 1/8 in.) in height. In most cases the lateral arms of such crosses are at an angle of less than 90°, the usual angle being 50°.

The St. Andrew's cross is put up :

In *Germany,* at all level crossings on main and secondary lines, even at those which were never closed or guarded, except in the case of clearly visible and little used crossings. The signs are set up 5 m. (16 ft. 5 in.) from the track. When there are several lines the cross is double (fig. 2 and 3, page 1296 of our report).

In *South Africa,* the cross is set up 100 yards from the level crossing. Near the track there is a notice with the word « Stop » painted on it in black. The cross and the notice are painted aluminium colour.

In Belgium.

In *Bulgaria,* it is proposed to erect such signs only at the principal level crossings without keepers.

In Canada.

In *Denmark,* it is also proposed to erect 100 m. (328 feet) from the level crossing a notice board calling the attention of the road users to the maximum speed of 20 km. (12.4 miles) an hour.

In *Spain,* the erection of signs of this type is under consideration.

In *Egypt,* the St. Andrew's cross is fixed on a disc, and the whole signal is thickly studded with 240 red cat's eye reflectors.

In the *United States of America* — together with a notice indicating the number of lines, when there are two or more (fig. 20, page 366 of Mr. Newlands' report).

In *Finland,* the St. Andrew's cross or notice boards of the old type with the notice « Beware of trains » are used.

In *France,* at level crossings where the

visibility is poor and the traffic heavy, on certain railways.

In *Italy*, in the case of all level crossings without keepers. Rectangular notice boards are permitted in their stead.

In *Norway*.

In *New South Wales* (Australia).

In *New Zealand*, 440 feet from the level crossing (cf. page 356 of Mr. Newlands' report).

In *Holland* and the *Dutch East Indies*.

In *Poland* such signs must be erected at all level crossings without keepers.

In *Sweden*.

In *Switzerland*.

In *Czechoslovakia*.

In *Jugoslavia*, at the present time only at level crossings where keepers used to be employed until recently.

Fixed signs in the form of a St. Andrew's cross are not employed in *Great Britain, Luxemburg, Portugal* or *Turkey*.

Conditions under which the existing regulations allow level crossings without keepers.

This question was only put to the railway administrations covered by our questionnaire. It is therefore only possible to quote the information given by the administrations who replied to this particular questionnaire.

In *Germany*, according to §§ 18 (3) and 46 (5) of the *E. B. B. O.*, apart from level crossings on main lines which must all be fitted with gates, the other level crossings are classified according to the following rules :

Visibility.		Speed of train at the crossing, (in km. - *in miles* - per hour.)	Must barriers be provided ?	Is supervision enforced ?
Good	with heavy traffic	< 15 (*9.3*)	No	No
		15-40 (*9.3-25*)	Yes	Yes
		> 40 (25)	Yes	Yes
	with light traffic	< 15 (*9.3*)	No	No
		15-40 (*9.3-25*)	No	No
		> 40 (25)	No	Yes
Bad	with heavy traffic	< 15 (*9.3*)	Yes	No
		15-40 (*9.3-25*)	Yes	Yes
		> 40 (25)	Yes	Yes
	with light traffic	< 15 (*9.3*)	No	No
		15-40 (*9.3-25*)	No	No
		> 40 (25)	No	Yes

In *Poland*, the new regulations on the safety of traffic at level crossings classifies these into 4 groups :

1. Crossings without keepers, without gates, and having no signals giving automatic warning of the approach of trains;

2. Crossings without keepers, without gates, with automatic signals giving warning of the approach of trains;

3. Crossings with keepers thereat, closed when trains pass, or normally kept closed;

4. Crossings worked by a keeper from a distance, closed when trains pass.

There are also private level crossings, normally kept shut, which can be opened by the users when required.

Much frequented level crossings (total

of the trains during the 24 hours and number of the road vehicles per hour of a maximum density exceeding 200) should be classified in the third group.

Furthermore, those crossings where the road crosses more than two main lines or crosses station lines used for shunting, must have keepers and be classified in group 3 or 4.

Level crossings where there is less traffic than in the preceding cases (total of the trains during the 24 hours and number of the road vehicles per hour being less than 200), with sufficiently good visibility, are classified in the 1st group.

All level crossings where the speed of the trains does not exceed 15 km. (9.3 miles) an hour are also classified in the 1st group, no account being taken of the density of railway or road traffic.

When the visibility is poor, these level crossings are classified in groups 2, 3 or 4.

Provision is made for concessions to be made for lines on which the speed of the trains is limited to 50 km. (31 miles) an hour; on such lines level crossings where the visibility is altogether lacking, or the road traffic is less than 150 vehicles in 24 hours in both directions taken together, are classified in group 1.

In *Bulgaria* keepers are not provided at level crossings when the visibility is sufficiently good. Moreover level crossings on roads where there is little traffic have no keepers even when the visibility is poor.

In Czechoslovakia, the general regulations concerning secondary lines do not make either gates or keepers obligatory.

The statistics relative to traffic over level crossings in the State of New York for 1925 quoted on pages 1314 and 1315 of our report show that the average product of the number of vehicles which cross a level crossing in one day multiplied by the number of trains running in one day on the given line represents, in the case of level crossings without keepers fitted with visual signals, 68 261, i. e. about 70 000, and in the case of certain level crossings reaches the figure of 106 000 and even 184 000.

In Germany, France, Czechoslovakia and Jugoslavia, when the level crossing is over two or more lines the St. Andrew's cross is doubled.

In Poland only the lower arms are doubled.

In Canada, the United States and Italy, signs with several arms are not used, but a notice board is provided in addition to the sign.

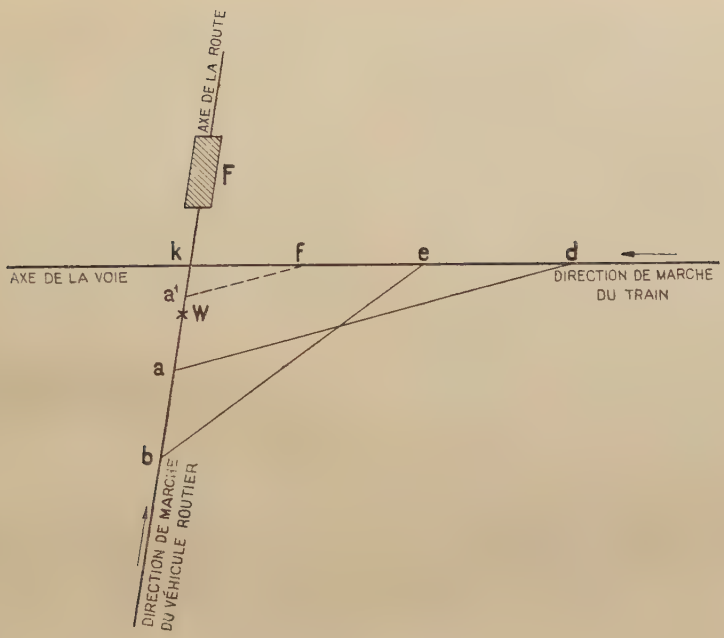
Conditions of visibility.

In all three reports by Mr. Baticle, Mr. Newlands, and ourselves, the most definite and concrete replies on this subject were received from Germany, Denmark, Poland and Czechoslovakia.

In *Germany*, according to the information published by the Geman Railways, visibility at a level crossing is considered good when there are at least the following triangles of visibility :

a k d,	visibility triangle for slow moving vehicles.
b k e,	visibility triangle for fast moving vehicles.
a' k f,	visibility triangle for pedestrians (at crossings reserved exclusively for pedestrians).
a and *b*	are situated at 1.30 m. (4 ft. 3 3/16 in.) above the crown of the road.
d and *e*	are situated at 1.50 m. (4 ft. 11 in.) above the head of the rail.
W k	distance of the cruciform signal from the nearest rail(usually.5 m. = 16 ft. 5 in.).

a W = 3 m. (9 ft. 10 in.).
b W = 15 m. (49 ft. 2 in.).
a' k = 3 m. (or the nearest rail).
k d = 5 V in metres, where V represents the maximum permissible speed, in kilometres, at the crossing.
k e = 3 V.
k f = 2.5 V.



Explanation of French terms :

Axe de la route = Centre line of road. — Axe de la voie = Centre line of track. — Direction de marche du train = Running direction of train. — Direction de marche du véhicule routier = Running direction of road vehicle.

In *Denmark,* the conditions under which visibility is sufficiently good are determined in the following way : on the road about 30 m. (98 1/2 feet) from the nearest rail the railway track should be visible in both directions for about 200 m. (656 feet). In addition from the road, 10 m. (33 feet) from the railway, the railway track should be visible in both directions for 300 m. (982 feet). If any building interferes with the view of the track immediately before the crossing, the visibility is considered good it it is sufficiently extensive before the obstruction in question.

In *Poland,* during the day the approaching train, and during the night the head lamps of the train should be visible from the road over its full width, at least 10 m. (33 feet) from the outside rail in both directions, during the whole time the train is approaching, from a position L metres from the crossing.

The distance L is defined by the following dimensions :

a) For the crossing of a single track on lines of general importance L = 5.5 V-max.;

b) For the crossing of a single track on lines of local importance L=5 V-max.;

c) For the crossing of two tracks, having a distance between their centres lines of 6 m. (19 ft. 8 in.), L = 7 V-max.

In the above particulars, V-max. represents the maximum permissible speed for trains on the line in question (in kilometres per hour).

Crossings on roads carrying automobile traffic, belonging to category 1, ought to comply, according to the conditions of visibility mentioned above, with an additional requirement, namely, that the train, in covering the section of the track

L′ = 3 V-max. in front of the level crossing, should be visible from every point on the road, along a length of 20 m. (65 ft. 7 in.) at least, on both sides of the outer rails.

For crossings having two tracks, the distance L′ is increased by 0.075 *d* V-max.

For the computation of the distances L and L′ the speed V-max. is taken not below 40 km. (25 miles) per hour, even if the speed allowed on the line in question is less.

In special cases, when the maximum speed is not reached at the approach to crossings, the regional managements of the State Railways can fix, specially for this crossing, a visibility from the train conforming with the maximum actual speed at the approach to the crossing.

On lines used by trains with every axle braked, distances L and L′ may be reduced with the consent of the Ministry of Communications.

In *Czechoslovakia* the minimum distance on the road at which the train must be sighted is 4 m. (13 ft. 1 1/2 in.). It is at this distance from the centre of the adjacent track that the warning cross (St. Andrew's) is erected.

As regards the distance of the approaching train at the time it must be seen by the road placed at the distance mentioned above, the following conditions have been decided upon.

The driver of the road vehicle, on the point of traversing the unsupervised crossing, ought to perceive the head of the train approaching the crossing in sufficient time to enable him to drive his vehicles across the so-called dangerous zone of the crossing, before the head of the approaching train has reached it. This zone extends to 2.50 m. (8 ft. 2 7 16 in.) on each side of the centre line of the track. On the basis of these conditions are determined the distances referred to, taking into consideration, on the one hand, the maximum speed of the trains running on the line, and on the other hand the maximum length of the road vehicles. These distances, based on the different categories of speed allowable on the Czechoslovakian Railways are comprised in the following table :

Maximum speed permitted in km. (*miles*) per hour.	Distance on			
	local (secondary) lines.		main lines.	
	Single track only.			
	metres	*feet*	metres	*feet*
40 (25) and less .	200	(656	250	(820
50 (*31*)	250	(820)	300	(984)
60 (37.3)	...		350	(*1148*)

For level crossings where there are several tracks the distance indicated in the above table is increased by as many times 50 m. (164 feet) as there are tracks crossed by the road. For intermediate speeds the distance entered for the next higher speed is taken.

Audible signals given by the train driver.

The driver is not obliged to whistle when approaching level crossings in Belgium, Denmark, Holland, Sweden, Switzerland and Turkey.

He is obliged to whistle in Brazil, Spain, Japan, Luxemburg, Norway, Portugal, on the Smyrna-Cassaba Railway; in Germany before level crossings with heavy traffic; in the United States in some States 400 m. (1 312 feet) from the crossing; in Finland, before crossings with keepers at a distance equivalent in metres to 4 times the maximum speed of the train in km. h.; in Great Britain before level crossings without keepers; in France before certain level crossings; in Italy before important level crossings; in Poland before level crossings without keepers and poor visibility on less important lines where no automatic signals give warning of the approach of the train; in Czechoslovakia, in more or less

similar cases; in Jugoslavia before level crossings hidden from the driver.

Colours used in connection with signs at level crossings.

The colours adopted for the signs and gates in the different countries are :

Red and white : in Germany, Belgium, Denmark, Spain (Andalusian Railways), Finland, France, Italy, Norway, Holland, Poland, Portugal, Sweden and Switzerland.

Black and white : in Spain (Madrid-Saragossa-Alicante Railways), the United States, Italy, Dutch East-Indies, Czechoslovakia and Jugoslavia.

In order to improve the visibility during the night, cat's eye reflectors are used which catch the light from the headlamps of motors in the following countries :

South Africa, Australia (New South Wales), Egypt, Spain, Finland, France, Great Britain, Italy (on trial), Holland, Switzerland, Czechoslovakia and Jugoslavia.

Résumé and remarks.

The laws and regulations of certain the laws and regulations concerning level crossings differ appreciably from one country to another and in the United States even from one State to another. This difference is found both in the dates at which the laws and regulations were promulgated and also in their content and the manner of dealing with the problem. There are regulations which were drawn up 100 years ago and have not yet been replaced by others, and there are others of quite recent date. In certain countries there are still regulations which require the gates to be kept normally shut across the track and only opened to allow a train to pass, such gates being opened by the actual train staff. In other countries the automatic visual signal, the most modern system, has already become generally accepted and the road user having to cross the railway is required to give his full attention to avoid an accident, his carelessness in this matter being qualified as punishable negligence.

The road traffic which formerly had a purely local character has now changed into fast long-distance mechanised traffic and to a large extent international. It would be a great advantage if the laws and regulations as well as the methods of protecting level crossings resulting therefrom and likewise the obligations imposed upon the road users were the same in every country.

There are no good reasons why the form of the signs, the gates, their lighting, visibility conditions, the obligation of slowing down or stopping before level crossings should not be the same everywhere, and likewise there is nothing to prevent these things being made uniform as soon as possible, successively in accordance with local needs.

To do this all that is necessary is to define clearly the way in which such uniformity can be obtained, both as regards the method of protection used, the form of the signs, and the regulations concerning the road traffic.

The laws and regulations of certain countries have recently made available much valuable material for investigations of this kind. The recently isued regulations follow the recommendations of the London Congress as regards suppressing keepers, making the signs and signals uniform, and generally revising the regulations based on out-of-date ideas in order to facilitate traffic over level crossings and diminish the cost of protecting them.

The information received concerning the laws and regulations in Australia, Canada, United States of America, Finland, France (particularly as regards automatic signals giving warning of the approach of trains), in Italy, Poland, Switzerland, Czechoslovakia, Jugoslavia, and in part of South America, especially Bra-

zil, is very valuable from this point of view and can serve as an example. The laws in force in South Africa and India also include up-to-date prescriptions.

As far as regulations concerning the road traffic is concerned, the obligation to stop before a level crossing is in force in Switzerland, New Zealand at important level crossings, in Georgia (U. S. A.) if the visibility is poor, and in the province of Quebec if there are no automatic signals.

A reduction of speed is obligatory in Australia, Belgium, Georgia, Holland, Poland, Virginia, Germany, Finland and Switzerland.

We are of the opinion that vehicles should be obliged to stop before level crossings not fitted with automatic signals if the visibility is poor. At level crossings without keepers with good visibility or automatic signalling, the speed of the road traffic should be limited to 25 km. (15 miles) an hour, a lower speed being in practice too difficult for motor vehicles [it is difficult for example to travel at 10 km. (6.1 miles) an hour, a speed recommended in some countries, without changing down], and when vehicles are running at this speed they can be stopped instantly. In both cases, when stopping and when slowing down, the regulations should be made known to the public by notices to this effect on the signs.

The advanced warning sign on the road is rapidly becoming the rule on most railways. In Europe, in accordance with the International Convention of 1926, triangular signs are chiefly used. In Great Britain and Luxemburg a different sign is used.

In Europe the advanced warning sign is erected 150 to 250 m. (492 to 820 feet) before the level crossing. Apart from Europe, a sign of this type is used in Brazil. In other parts of the world advanced warning signs of many other types are used. The United States of America have a type of their own which is widely used.

Outside Europe the advanced warning sign is usually placed nearer the level crossing, for example 150 to 600 feet. The American Railway Engineering Association recommends a distance of 60 to 135 m. (200 to 440 feet). Mr. Newlands in his report gives the distance for the United States as 180 m. (600 feet).

In Germany if the distance is 200 m. (656 feet), similar posts to those used in Switzerland must be set up at 50-m. intervals (every 164 feet) between the warning sign and the distance indicating posts (fig. 9, p. 1326 of our report).

It is desirable that a uniform type of advanced warning sign be employed everywhere and that this should conform to the type fixed by the Convention of 1926, except in America where the type recommended by the American Railway Engineering Asociation is to be recommended.

The decision of the International Convention of 1926 as regards the distance between the advanced warning sign and the level crossing should be completed and this distance normally fixed, taking the practical results obtained in America into account, at 150 m. (492 feet) at the most before the level crossing, the minimum figure given by the Convention, and at 60 m. (200 feet), at the least [not less than 30 m. (100 feet) in towns]. On roads where the motor traffic is very heavy this distance could be increased to 200 to 250 m. (656 to 820 feet) and distance indicating posts should be erected every 50 m. (every 164 feet) as in Switzerland (cf. fig. 9, p. 1326 of our report).

As far as the division of the cost of protecting level crossings or suppressing them is concerned, the replies received from the countries consulted show that it is being more and more understood that such work is made necessary by the development of the motor traffic and the opinion held until recently that the whole of this expense should be borne by the railway is no longer current. In-

teresting information on this subject was received from the following countries :

Germany, where the expense is borne by the railway or by the road according to whether the work is made necessary by the needs of the railway or the road traffic.

Canada, where the Treasury shares in such expenditure up to 40 % of the cost and as a maximum including the participation of the Municipalities, 54 %.

In the United States, the participation of the Treasury is 50 % on the average, varying from 10 to 100 %.

Poland, the cost is borne by the railway or by the road authorities according to which of them began the work in question.

Cezchoslovakia, the expenses are divided up in proportion to the advantages obtained.

In principle, the railway should not have to bear the cost of making or maintaining a level crossing where the employment of a keeper or the signalling is made necessary by the construction or the improvement of the road. In cases where a bridge or subway is made it is the road traffic that obtains practically the whole of the benefit. The railway should only have to share in the cost to the extent of the sum representing the cost of protecting and maintaining the level crossing in terms of capital. An exception can be made in cases in which the railway takes the initiative in carrying out such work, this being dictated by its own interests, but even in such cases the improvement in the existing conditions at the level crossing should be at the expense of the Municipality (for example the widening of the crossing, better paving, etc.).

Level crossings with keepers but no gates are not found in any great number except in New Zealand where gates are never used, in Turkey and the United States, where only 3 % of the crossings are guarded in this way and the number decreases from year to year.

In the United States the question of gates automatically shut by the train is being investigated. Judging from the replies three such level crossings are in use in Canada.

Because of the increase in motor traffic an attempt has been made to improve the visibility of the gates by lighting them and by painting them bright colours. Many railways do not consider it really advantageous to fit gates with red lamps, as these can be hidden by vehicles or mistaken for the rear light of a car. In Germany and Finland it is considered advisable to erect near the gates of level crossings warning signs in the form or a St. Andrew's cross, or some similar pattern (in Germany).

The present method of painting the gates and the attention paid to fitting them at night with red lights does not prevent the number of accidents due to collision with the gates from being considerable (84 % of the total motor accidents in Czechoslovakia, 47 % of the total number of accidents at level crossings fitted with gates in Germany), and consequently these methods do not attain their object in most cases. It can therefore be considered advisable to give up those systems of protection which are troublesome and expensive, especially the use of lamps, and to be content with painting the gates in bands of colours, fitting them with reflectors and when the traffic is heavy, lighting the crossing properly. This last method especially should be given attention, if as we think likely, the use of gates will be given up in the future, except in the case of crossings where the traffic is very heavy.

The minimum interval of time before the arrival of a train at which the gates should be shut is 2 minutes. The longer the gates are shut the more the road traffic is inconvenienced. In France the best method of warning the keeper of the approach of a train is in use or being introduced, the use of an automatic elec-

tric bell for this purpose. We are of the opinion that this type of warning is already a step forward towards protecting level crossings automatically, without using either gates or keepers.

Most of the railways in the case of distant operated crossing gates do not require the crossing to be visible to the keeper, since they do not find the want of visibility gives rise to any special drawbacks. It therefore appears that in special cases visibility is not indispensable. The distance between the crossing and the keepers' post is as much as 1 500 m. (4 920 feet).

Automatic signalling of the trains is very widely used it the United States (at 15 213 level crossings); there is also a considerable number of such installations in Australia, Canada, Italy, Japan, New Zealand, Sweden and Switzerland. Such apparatus is being installed for trial purposes in Germany, South America, Belgium, Brazil, Ceylon, Finland, Italy, Norway, Poland and Switzerland.

According to Mr. Baticle's report and our own, the following have expressed a favourable opinion as regards the future use of these appliances: Germany, Belgium, Denmark, Spain, Finland, Italy, Norway, Poland and Switzerland.

Mr. Baticle finds that : « whenever the visibility is poor and the railway traffic heavy, the stop signal to be shown should in principle be the gates ». But at the same time he remarks that the crossing keeper will satisfactorily carry out his duties if the train is signalled to him by telephone or automatic warning signals, the pedal of which is for exemple 2 000 m. (6 560 feet) away from the level crossing.

Basing our opinion on the information supplied and the experience we have acquired, we come to a different conclusion from that of our worthy co-reporter. In view of the high speed motor traffic, we do not think that gates are the best stop signal. A gate closed across the road is a measure which should protect the road users from possible accident, but which in actual fact, as the statistics of accidents due to collisions with the gates quoted above, in the case of road motor traffic show, is in itself dangerous. By replacing the gates when the intensity of the traffic makes this possible by automatic or fixed signals, according to the degree of visibility, we are following the recommendations of the London Congress which advised the suppression of keepers, and thereby diminishing the inconvenience to road traffic of too prolonged a wait and this in our opinion will increase the safety.

Today in view of the world crisis, the great number of unemployed and the unduly large staff of the railways, it may be that the suppression of keepers appears to be a less pressing question than it did some years ago. But with the return of normal conditions and the necessity for carrying out railway operation as cheaply as possible, if only in view of the competition of the road transport undertakings, the tendency to suppress keepers would surely be strengthened.

We must admit that the present tendency is to give the first place to automatic light signals, placing these on the same footing as gates, or higher. As the United States of America have obtained much experience in the use of such signals, we will even go as far as recommending the use of the type adopted by the American Railway Engineering Association completed by a notice requiring vehicles to slow down over level crossings (fig. 8, p. 1323 of our report.

The distance at which the train should be from the level crossing when the automatic apparatus begins to work should be such that the apparatus begins to work before the fastest train reaches the crossing. It is 20 seconds in the United States, 30 seconds in Germany, Italy and Poland, and 30 to 45 seconds in Switzerland. Too long a time is disadvantageous because of the temptation to risk

crossing at the last moment. We think that the time might be fixed at 20 to 30 seconds and that the apparatus should continue to function until the last wagon of the train has passed over the crossing. Accidents due to motors running into the trains when passing over the crossing have led us to adopt this opinion.

If the line is clear, the automatic signal should show a white light flashing 30 to 40 times a minute. When a train is approaching the white light should be covered by a red glass and flash twice as fast (80 times a minute). The acceleration of the flashing will make it possible for colourblind road users to recognise the signal. When the white or the red light is not flashing the apparatus is evidently out of order.

We are in favour of signals with flashing lights with the characteristics mentioned above. In countries where wigwags signals are in current use (Canada and the United States west of the Mississipi), the standard type of the American Railway Engineering Association is the one to be recommended (fig. 21, p. 367 of Mr. Newlands' report).

At level crossings without keepers where automatic signalling is not used, the St. Andrew's cross sign has been adopted by the following countries : Germany, South Africa, Belgium, Bulgaria, Canada, Denmark, Egypt, Spain, United States, Finland, France, Italy, Norway, New Zealand, New South Wales (Australia), Holland and the Dutch East Indies, Poland, Sweden, Switzerland, Czechoslovakia, and Jugoslavia.

Such signs are not used in Great Britain, Luxemburg, Portugal and Turkey.

On level crossings over several lines, the lower arms of the cross should be doubled, as in the type recommended by the International Railway Union (U. I. C.).

We think that such signals should be erected in the first place at level crossings without keepers on all roads where there is important international traffic, then on roads with motor traffic, and finally at all level crossings on roads with less traffic, in accordance with the regulations.

The conditions laid down by the existing regulations upon which we have received information making it possible to have level crossings without keepers are too cautious to meet present day requirements. Unfortunately our own report alone contains any information upon this matter. The statistics of the State of New York gives the figure of 68 261 as the average product of the number of vehicles multiplied by the number of trains in one day over level crossings without keepers, but fitted with visual signals. In the case of certain crossings this figure is as much as 106 000 and even 184 000 (pages 1311 to 1315 of our report).

In our opinion the figure 70 000 is acceptable provided that the number of trains is not more than 100 and that below this number the level crossings should be in principle without gates.

As far as visibility is concerned, the following conditions could be observed :

The distance between the rail and the place on the road from which the train must be visible :

— in the case of horse-drawn vehicles (slow) : 8 m. (26 ft. 3 in),

— in the case of road motors (fast) : 20 m. (65 ft. 7 in.) ;

The distances L on the railway track from which the train must be visible :

— in the case of horse-drawn vehicles $L = (5 + 0.25\ d')\ V$ metres,

— in the case of road motors : $L = (3 + 0.075\ d')\ V$ metres,

in which d' = the distance between the centre lines of the tracks, and V = the maximum speed of the trains at that place in the given direction of running.

It is to be recommended that this sign be introduced progressively, as required as the motor traffic increases, on all level crossings without keepers and automatic signalling, whenever the speed

of the trains is not exceptionnally low, for example 15 km. (say 10 miles) an hour.

As visibility is essential and is more important and even more effective than having keepers at the crossings, it should be considered desirable to obtain such legislative changes as will ensure good permanently visibility.

The effectiveness of the signal given by the locomotive whistle becomes more and more doubtful, owing to the variability of the train speeds as well as the very differing speeds of horse-drawn vehicles and motors. It is further lessened as regards the drivers of road motor vehicles by the noise of the engine and by the greater use of interior drive vehicles.

In addition, the attention of the driver must not be distracted, as his chief duty is to observe the block and station signals.

We consider therefore that the use of the whistle should be limited to unprotected level crossings dangerous because of poor visibility and not provided with automatic signalling.

Most of the railways use white and red for painting the gates and signs. As a considerable number of the railways have had satisfactory experience of devices reflecting the light from the motor head lamps, their use at indifferently lighted level crossings can be recommended. The most effective method of increasing the safety at level crossings with heavy traffic and with gates will however always be to light them up properly.

The problem of the equipment of road and railway crossings has to be considered under the following headings :

I. — Over and under crossings.

II. — Unprotected level crossings with automatic or fixed signals.

III. — Level crossings with gates.

As regards No. 1, the question of building over and under passager in place of existing level crossings should be considered from another point of view than that usual up to the present. In view of the available methods at present employed for signalling the approach of a train, the level crossing should be considered merely as a place on the road where the traffic under certain conditions is more difficult and not as a more dangerous place than the crossing of one road with another, with heavier traffic.

The decision to build an under or over-passage should therefore be based upon an estimate which would take into account the approximate capital value of the financial loss due to loss of time by the road traffic whilst the vehicles are waiting for the train to pass in comparison with the cost of suppressing the level crossing reduced by the total expenditure for signalling or for protecting the passage.

If we use the statistics already given for the State of New York (pages 1311 to 1315 of our report) we consider that the question of replacing level crossings by under or over passages should be considered when the number of trains during the 24 hours exceeds 400, or if the product of multiplying the number of trains by the number of vehicles per day exceeds 800 000, when the number of trains exceeds 100 in 24 hours.

Mr. Baticle has put forward in a most interesting manner (pages 1683 and 1684) the inconvenience caused to the road users by the interference with the traffic and the loss of time caused by lengthy stops at level crossings. We can only add to his interesting remarks the single observation that the road circulation meets more or less the same difficulty at each road crossing. One should not therefore require more of the railway than of road crossings. The low speed and the loss of time at the busiest hours in the main streets of Paris, London, New York, Chicago and other large centres are well known. In

the United States the number of persons hurt through accidents at railway level crossings in 1926 was only 1.5 % of the total of wounded and killed as the result of accidents on the public roads and at road crossings.

We see therefore that the question of the safety at crossings is not so alarming that it should decide us to incur the heavy expenditure involved in supressing level crossings.

From the replies from the different countries who have advised us of the number of under and over passages built since 1926, we see that this number represents 1/840th of the total crossings of roads with the railways, and the cost of replacing all the existing level crossings by over and under passages is in the United States calculated at 50 to 75 % of the total value of the railways (pages 1312 and 1313 of our report).

The result of this is that the principle involved in I will not in the future be a major one and it will therefore be a question of making a choice between II and III.

II, level crossings without gates, is a solution which interferes with the road circulation less than III, the road traffic only being stopped when the train is approaching and continued immediately after the train has passed, whereas the system of keepers closing and opening crossing gates especially if the service should be carried out carelessly causes more time to be lost.

Mr. Baticle is of the opinion that with level crossings with gates, as the result of the increase in high-speed road motor traffic, the gates should be looked after by a more highly qualified staff which of course would be more costly and that these level crossings should be fitted with apparatus signalling the approach of the train. Consequently II, whether it is a question of fixed signs or automatic signalling, will be less costly than No. III.

If, on the other hand, we take into consideration the many accidents resulting from road vehicles colliding with level crossing gates, (84 % in Czechoslovakia and 47 % in Germany), and the necessity for disciplining the road users, by obliging them to study the regulations and the precautions to be taken, we see that from the point of view of safety, II is better than III.

It would appear to be necessary to make it quite clear in the event of signalling of level crossings being required by law that the railway administration is not responsible for accidents occurring at level crossings, just in the same way as the road administration is not responsible in the case of accidents occuring at crossings of public roads.

The replies to our enquiries prove that most of the railways in accordance with the recommendations of the London Congress and taking into account the above considerations as also the necessity of reducing costs, are deciding to adopt II. Their efforts in this direction, however, have not been co-ordinated, and the installations carried out at level crossings are of very different types.

This is not surprising as it would not be possible to standardise the equipment except by drawing up rigid regulations settling the problem of the protection of level crossings and laying down the types of signs and the conditions of visibility.

In order to show how far the arrangements used in the different countries are from being co-ordinated, Germany, Italy and Yougoslavia may be mentioned, these countries having accepted the international decision to use the St. Andrew's cross sign, this sign having been placed :

in the case of Germany at all crossings,

in Italy at crossings without keepers,

in Jugoslavia, at crossings at which keepers have recently been taken away.

This shows that a sign applied in this way can, for the international road user, create a danger, and that in any event it ceases to be understandable as a warning.

In view of the preceeding, we have endeavoured to put forward a proposed regulation dealing with the protection of level crossings, the types of signs and the conditions of visibility, based upon the information sent and our study of it.

The resulting solutions which tend to improve and standardise the installations for protecting level crossings, obviously will involve considerable expenditure. We should understand therefore that it would not be possible to put them into force except gradually as they became essential, or as the necessary financial means made it possible.

Proposed uniform regulations for the rotection of railway crossings ; signal types and visibility conditions.

On the basis of the preceding résumé the following principles may be extracted bearing on the protection of crossings as well as on the types of signals and the conditions of visibility.

1. *Arrangements for the protection of crossings.*

At crossings on lines where the speed does not exceed 15 km. (9.3 miles), if there is automobile traffic on the road, a triangular sign, in accordance with the Convention of 1926, is considered to be sufficient.

In the cases where the crossings on the lines in question would not have a sufficient visibility, it would be necessary to instal, at a distance of L = 5 V = 75 m. (247 feet) alongside the track, signals instructing the driver to whistle and, if there is automobile traffic, a similar supplementary signal at a distance of L = 3 V = 45 m. (147 ft. 8 in.).

At crossings of good visibility and in cases where the speed of trains is greater, it would be necessary to erect, on both sides of the line, fixed St. Andrew's cross signals (figs. 4 and 5 of our report); in case there is automobile traffic, triangular signals, in accordance with the 1926 Convention, would be erected.

In cases of insufficient visibility, it is necessary, instead of the fixed St. Andrew's cross signal, to erect an automatic optical signal surmounted by a similar cross (fig. 8 of our report, reproduced hereafter) with the addition of bells if there is an exceptionally heavy traffic of pedestrians.

These two systems of protecting level crossings are sufficient when the product of the number of vehicles and the number of trains in 24 hours is not over 70 000, if, however, the number of trains is not greater than 100.

If the traffic on the road is more intense than that in question above (> 70 000), barriers must be utilised, painted in white and red and well lighted, and exceptionally, provided with reflecting lenses if a sufficient illumination is difficult to obtain.

These barriers ought to be closed two minutes before the arrival of the train. An installation of automatic bells is recommended to warn the gatekeepers of the approach of the train.

The distance between the barrier and the centre of the adjacent track may be fixed at 3 m. (9 ft. 10 in.) as a general rule, and at 8 m. (26 ft. 3 in.) for barriers operated at a distance of :

I. Less than 50 m. (164 feet) if they are not clearly visible from the control post;

II. More than 50 m. (164 feet) if they are not clearly visible from the post and if the ringing of the bells is not of sufficient duration to enable the crossing to be traversed.

As an exception, it is permissible to replace automatic signalling, even in the event of absence of visibility, by fixed signals, when the speed of the trains is not greater than 50 km. (31 miles) per hour and the number of vehicles does

not exceed 150 in 24 hours, with few motor buses among the vehicles; in this case it would be necessary to order compulsory stopping of the vehicles and to instal signals at a distance of $L = 3\ V$ and $L = 5\ V$, instructing the driver to whistle.

Barriers would have to be replaced by over or under bridges if the product of the number of trains and the number of vehicles in 24 hours is greater than 800 000, or if the number of trains exceeds 400 in 24 hours. Exception would be made for lines having trains of the tram type.

At crossings requiring partial supervision during the day, it is necessary nevertheless to provide fixed signals, or if the visibility conditions demand it, automatic signalling and no barriers. The barriers, raised at periods of non-supervision are misleading to users of the road.

There will be found below the scheme of signal types as well as that of the visibility standards.

2. *Scheme of signal types and instructions for their installation.*

To be adopted, uniformly, the St. Andrew's cross shape, as shewn in fig. 4 (1), the lower arms to be duplicated at crossings having several tracks, in accordance with figure 5. The signal should be placed at a distance of 5 m. (16 ft. 5 in.) from the outside rail, at the side of the road on both sides of the railway. The post should be painted grey, the arms of the cross alternately white and red. On the post of this signal there should be affixed a board, size 30 × 60 cm. (11 3/4 × 23 1/2 inches) with the inscription, say, « 25 km. » (« 15 miles ») in white letters on a black ground. It would be recommended that to these letters should be fitted lenses for reflecting the light from automobile head lamps.

At crossings where the stopping of vehicles is compulsory, these boards would have dimensions of 55 cm. by 60 cm. (21 3/4 in. × 23 1/2 in.) with the inscription « Stop ! » in the language of the country, and above the inscription « 0 km. » (0 mile) for international traffic.

Preference must be given to automatic flash light signals, with the lights placed horizontally on both sides of the post, at a distance of 76 cm. (2 ft. 5 7/8 in.) between the lenses and at 2.40 m. (7 ft. 10 1/2 in.) at least, above the level of the road, as shewn hereafter.

At crossings with less intense road traffic, signals may have only one light, set on a post at the side of the road, at a distance of 38 cm. (15 inches) from the centre of the post.

The white light of automatic signals ought to flash continuously at the rate of 40 times per minute; during 30 seconds, as a minimum, before the arrival of the train a red light must flash at the rate of 80 times per minute.

The flashing of the red light ought to continue until the last wagon of the train has left the crossing. For the lighting of the signals electricity is used, or in default of this, acetylene.

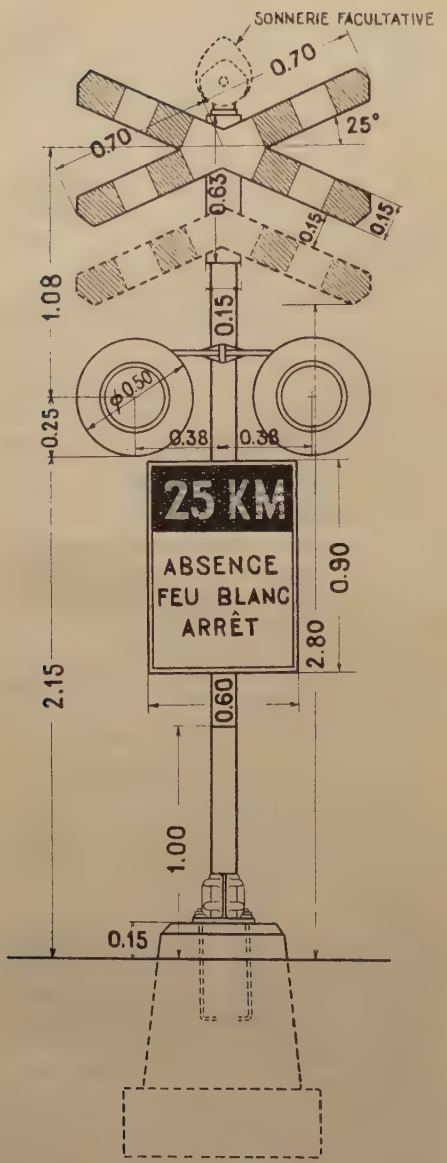
The optical signal ought to be surmounted by a St. Andrew's cross whose arms ought not to stretch beyond the limits of the flash lights.

A supplementary bell signal is not compulsory. On the post of the automatic signal would be placed boards carrying the inscription, say, « 25 km. » similar to the model specified for fixed signals and, also, a warning to stop in case of absence of the white light.

The nearest approach to the above description is the type of signal adopted by the American Railway Engineering Association. This type, modified according to the principles mentionned, is reproduecd hereafter.

The fixed or automatic signal, on roads having automobile traffic, ought to be preceded by a sign, in accordance with the 1926 Convention, painted in white

(1) Of our report.



Proposed automatic signal with flashing lights.

Note — The figure 25 km. is to be taken as an example only and may be altered to suit the needs of each country.

Explanation of French terms :

Sonnerie facultative = Optional bell. — Absence feu blanc, arrêt = Stop if white light is not shown.

and red, placed at a distance of at least 60 m. (197 feet), [in towns not more than 30 m. (98 1/2 feet)], but not exceeding 135 m. (443 feet), as is practised in the U. S. A.

In the case where this signal would be fixed at a greater distance from the crossing (up to 250 m = 820 feet) it would be necessary to place, between the said signal and the crossing, distance-indicating posts as illustrated in figure 9 of our report.

3. *Scheme of regulations concerning visibility at level crossings.*

To be agreed that the conditions of visibility are sufficient, if the driver of the vehicle, which is moving along the road at a moderate speed, perceives the train at a distance $a\ k = 8$ m. (26 ft. 3 in.), on the section $k\ d = L = 5$ V, where V is the maximum speed which the train can attain at the given place and in the given direction; as a rule it is the maximum speed allowed on the line in question (fig. 7 of our report).

If the road is intended for and occupied by automobile traffic, the driver of a fast moving vehicle ought to perceive the train at a distance $b\ k = 20$ m. (65 ft. 8 in.), on the section $k\ c = L = 3$ V.

As for crossings with more than one track the above mentionned visibility distances must be increased, as follows :

$$k\ d = L = (5 + 0.25\ d)\ V;$$
$$k\ c = L = (3 + 0.075\ d)\ V;$$

a and b are at 1.30 m. (4 ft. 3 in.) above the road level;

d and c are at 1.50 m. (4 ft. 11 in.) above the rail level.

SUMMARY.

These various observations have led us to certain summaries which can be expressed as follows :

1. The experience since the London Congress shows that the decisions taken to limit the number of level crossings with keepers have been generally justified.

2. As, thanks to the use of motor vehicles, road traffic, formerly local, has been transformed into high-speed traffic, over wider areas, and becomes more and more international traffic, the Congress could adopt a motion having as its object to invite the countries belonging to the International Association to introduce uniform legislation and regulations in all countries dealing with the protection of level crossings, uniform types of automatic and fixed signals and other equipment at the level crossings.

3. The most effective solution as regards the crossings of the roads with the railways, the construction of over and under-passages, can only be applied in limited cases to crossings of roads with very heavy traffic with main line railways.

This solution cannot be taken into consideration as a more or less general rule in view of the exhorbitant cost it would involve.

4. In the case of level crossings where the road traffic is of average intensity, it is desirable to consider that the automatic or fixed signals give a degree of protection which is not inferior to that given by the gates and have this advantage that they interfere less with the road traffic and prevent the accidents resulting from collisions with the gates, so frequently reported.

If the signalling of level crossings is required by the law it should be clearly laid down that the railway Administration is not responsible for accidents occurring at level crossings, in the same way as the road administration is not responsible for accidents occurring at crossings of public roads.

5. Fixed signs in the form of a St. Andrew's cross preceded in the case of roads over which the road motor circulation is heavy, by an advanced warning sign should be considered as sufficient protection so long as the visibility is good enough.

6. In the case of insufficiently good visibility, in place of fixed signs, the automatic signalling of the approach of the train should be introduced.

7. Fixed signs can also be placed at level crossings with inadequate visibility, if the railway traffic is limited as regards speed and the road traffic is not very heavy.

8. The gates should be retained at crossings with very heavy traffic on the road and on the railway, when the automatic signalling is not sufficient, and when keepers and the regulation of the road traffic appear to be necessary.

9. In the case of such level crossings, the crossing keepers should be recruited from qualified staff and the crossings should be, as far as possible, well lighted.

10. It is important that the work of the keepers should be facilitated by the trains being announced to them by the neighbouring signal boxes if they are near enough, or by a system of automatic signals.

11. To increase the visibility of the signs and of the gates they should be painted in white and red stripes so as to make them more striking to the eye and they should also as far as possible be fitted with cats's eye reflectors.

12. In view of the fact, on the one hand that the organisation of protection on the above lines might be very costly, and the construction of over and under-passages would be even more so, and furthermore that the road motor traffic at high speed does not select the shortest road, but rather a good one even if longer, and that consequently the road traffic is concentred on a restricted number of level crossings, an endeavour should be made to reduce as much as possible the number of road crossings with the railways by abolishing level crossings with little traffic, by diverting the traffic towards those which, having

a heavier road traffic, are fitted with adequate signalling systems and warning devices or gates, and by building under and over-passages at the places where the heaviest road traffic is concentrated. When drawing up schemes for building and rebuilding the roads, these circumstances should be taken into account.

13. As the increase of the difficulties at level crossings has been caused by the formerly unknown intensity of the road traffic, the road should assume the cost of constructing the over and under-passages as well as those for the additional protection of the crossings required by the growth of the road traffic.

14. It should be recognised that the realisation and maintenance of the conditions of visibility, governed by uniform regulations for level crossings in all countries, are of very great importance. The regulations should therefore be drawn up accordingly.

15. At level crossings without keepers which are very visible or are provided with automatic signalling, the speed of the road traffic should be limited to 25 km. (15 miles) per hour ; at crossings with inadequate visibility, and not fitted with automatic signalling, the vehicles should be required to stop.

In both cases these arrangements should be made known to the public by notices attached to the signs.

16. In order to unify the conditions of protection of level crossings, the opinion of the railways should be obtained by submitting to them the regulations proposed for adoption by the future Congress.

[625. 144 .4 & 625. 17]

QUESTION II :

The use of mechanical appliances in the permanent way maintenance and in track relaying,

by D. MENDIZABAL,

Special Reporter.

Having been requested, as special reporter, to present a summary of the reports on the above question, I have examined in detail the three reports, which are as follows :

Report No. 1 (United States of America, Great Britain, its Dominions and Colonies, China and Japan), by F. M. THOMSON (1);

Report No. 2 (Latin America, Belgium, Spain, France, Italy, Holland, Portugal and their Colonies, Denmark, Finland, Luxemburg, Norway, Sweden and Switzerland), by D. MENDIZABAL and J. GARCIA GARIN (2);

Report No. 3 (all other countries), by Mohamed Kamel EL-KHISHIN Bey (3).

There is nothing strikingly original about these reports, when compared with those presented to the last Congress, held at Madrid in May 1930; it is very evident that, on the one hand the short time that has since elapsed and, on the other hand, the narrow conditions in all countries of the world, rendering nearly impossible the adoption and development of new costly methods, have made it hardly possible to show any great changes in equipment.

In addition, the reporters have endeavoured to reach convincing and definite conclusions — at the same time bearing in mind their relative nature — derived from data and conditions which, in consequence of the crisis already referred to, have often been of an exceptional nature, not only because of variations of some importance in wages (these have been increased in some countries and lowered in others), but also because some of the experiments in the mechanical maintenance and renewal of the track have not been carried to a conclusion. This has been due to the difficulties produced by the problem of unemployment, an overwhelming problem in all countries.

Faced with the necessity for finding some solution to this problem tendencies and opinions hitherto considered immutable have received severe shocks, and if the situation remains substantially unaltered it may be necessary to face the prospect of a reduction in the length of the working day, in spite of the serious inconvenience such a measure would impose upon business in general.

Owing to these circumstances, the three reports in question and the present summary will perhaps show some incompleteness through no fault of their authors.

We will review the three reports in detail, reducing them to the same form so as to arrive at a single summary, with conclusions based on those of each of the separate reports.

The matter can be divided into two principal parts :

(1) See *Bulletin of the Railway Congress*, May 1932, p. 661.

(2) See *Bulletin of the Railway Congress*, August 1932, p. 1567.

(3) See *Bulletin of the Railway Congress*, June 1932, p. 953.

I. Mechanical appliances used.
II. Organisation of the work.

These two parts will be considered in succession.

FIRST PART.

Mechanical appliances used.

The greater number of the replies received from the administrations consulted, although they indicate the kind of machine employed, point out that they have not yet passed the period of trial and experiment, so that the results cannot constitute a definite and final criterion. We shall not describe here the machines employed, this information being contained in the respective reports. It will be sufficient to enumerate the operations which they perform in the maintenance and renewal of the track.

These appliances may be considered under three heads :

a) Appliances in almost continual use;
b) Appliances less frequently used;
c) Appliances used only occasionally.

a) *Appliances in almost continual use.* — These appliances, from the large use made of them, may be considered justified; they are used for the following operations which they carry out with a high degree of perfection :

1. Mechanically propelled trolleys for the transport of materials and men (both supervisory staff and workmen) to the place of work.

2. Transport of ballast in special wagons with rapid and automatic means of unloading.

3. Screwing and unscrewing screw-spikes or coach screws.

4. Tamping sleepers.

Mechanical methods of performing these four operations have given entire satisfaction, the administrations using them having found no cause of complaint.

b) *Appliances used less frequently, but tests of which have given good results.* — The mechanical methods of performing the operations mentioned below are the subject of much diversity of opinion among the administrations consulted :

1. Clearing away snow from the track. This presents considerable operating difficulties.

2. Screwing up the fishbolt nuts.

3. Cutting and drilling rails.

4. Sifting and grading ballast.

5. Adzing and boring sleepers. This work is infrequent in countries having much curved track necessitating sleepers of varying width with soleplates at different spacings.

6. Chemical and mechanical weeding.

c) *Appliances for one specific operation and consequently infrequently used :*

1. Unloading rails.

2. Unloading sleepers.

3. Mechanical consolidation of the formation and of the top ballast.

4. Laying-in completely assembled lengths of track.

With regard to the appliances necessary for the mechanical execution of the above operations, the reports of the administrations are, in general, favourable as regards the time required and the quality of the work done, but information is lacking especially as regards the results of investigation into and observation of the economic aspect of the matter. Such information would however be of great value in arriving at a decision or recommending a line of investigation.

The countries which have carried out work by mechanical means on the largest scale, and according to a definite programme, and which consequently give the most complete information, are the following :

1. The *Argentine,* especially the Bue-

nos Ayres Western Railway and the Central Argentine Railway.

2. *Germany,* the State Railway Company.

3. *North America,* in particular the Chicago, Milwaukee, St. Paul & Pacific Railroad, the Pennsylvania Railroad, the Boston & Maine Railroad.

4. *France,* the Nord Railway Company.

SECOND PART.

Organisation of the work.

The works that can be organised for mechanical appliances include normal and exceptional works of maintenance on the track, and its renewal by replacing the greater number of its parts.

It is natural that the results obtained by using mechanical appliances for these works should vary considerably, according to whether the trial is of a momentary or isolated nature due to a desire to test or interest in experimenting with a particular machine, or a new organisation of the staff; or whether it is a trial which, while not considered as conclusive (since everything admits of improvement, change or transformation), is however of a sufficiently lasting character as to have been anticipated by numerous preliminary trials.

It may also be noted that more weight can be attached to any conclusions come to when the trials have been carried out in different places and under varying circumstances; if there is agreement between the results obtained, we may then, as far as possible, consider the trial as conclusive and feel some confidence in the results obtained. It is for this reason that, although several of the administrations consulted have sent in models and types of organisation that have been tested — accompanied in a few cases by interesting economic results — the same weight cannot evidently be attached to each report, not because of a lack of confidence in the care with which the trial was made, or the preparation of the report or its exactiude, but because the range of application depends upon the above mentioned circumstances.

Leaving aside the less concrete and less categorical answers, we will summarise the more interesting replies below. They may be considered as falling into two groups, according to whether the trials have been of short duration and local in application, or on the contrary more closely investigated and more extensive in character; in the latter case the length of the trials is no absolute criterion for determining the final value of the statements made.

1. *The Argentine.* — Here the new organisation is applied specially to the tamping of sleepers by means of special gangs devoted exclusively to maintenance work. No statement is made as to the economic results obtained.

2. *Germany.* — Mechanical methods are employed for maintenance work properly speaking and for the renewal of track. The consolidation of the surface ballast and of the formation are now general practice, as well as the laying-in of completely assembled lengths of track.

The most recent trials were begun in 1925; the results have been quite satisfactory, but unfortunately the economic results obtained have not been given. The maintenance operations most frequently carried out are the tamping of the sleepers, the transport and unloading of ballast, and weeding.

3. *United States.* — The Chicago, Milwaukee, St. Paul and Pacific Railroad Company undertook maintenance works on a large scale in 1929, numerous gangs being established; a saving of 20 % on the expenditure of previous years has been realised.

For renewal work, also carried out by special gangs, the trials began in 1930; the special organisation of rail laying

has shown a saving of up to 40 %; ballasting the track with all the incidental operations has shown a saving of as much as 58 %.

Attention must be drawn to the extremely high cost of labour in the United States; other things being equal, such an economy would not be realised in other countries. The shortness of the trials should also be noticed.

The Pennsylvania Railroad Company has sent in an extremely interesting paper on the right lines, drawn up with the greatest care, omitting no details, calculations or theories whatever, which has enabled it to profit by its experiences and arrive at economic conclusions well worth consideration.

This Company carries out renewals by special gangs for removing the old track, laying rails, putting down the ballast, etc., these gangs being drawn from the hand-maintenance gangs.

This organisation has resulted in a saving of 40 % in rail laying and of 33 % in overhauling and general maintenance of the track.

The trials are quite recent, and as regards the economies realised the same observations and reservations apply as in the preceding case.

The general description of the work is given in great detail and shows that the organisation is nearly perfect.

The Boston & Maine Railroad Company also gives full and careful details of the operations it carries out mechanically, and shows in detail the cost corresponding to each phase of the work. The works comprise maintenance properly speaking, as well as renewal of the track, laying of rails, renewing of ballast, etc. The report also specifies the manner the operations are carried out, mentioning the workmen and machines involved; but apart from some satisfactory information on the results obtained no indication is given as to how the results compare with the same work carried out by hand, as regards the time taken, wages cost, or economy realised, so that it is consequently difficult to draw concrete conclusions.

4. *France.* — The French Nord Company has been renewing track by entirely mechanical methods for some years and quite recently has undertaken trials of a new method of carrying out the same operations.

The Company expresses its satisfaction with the speed and with the quality of the work; no mention is made of the economic results, which it would be interesting to know. Apart from the trials made by the German State Railway Company, these trials are in fact the most important undertaken in Europe, and their economic results would enable us to form a complete judgment on the advantages of such a process; but, as we have seen, the United States alone have furnished such data.

SUMMARY.

1. Although mechanical methods of maintenance and renewal of the track have been on trial and in use for some years, the results obtained have not been altogether favourable or generally adopted, nor such as could be recommended for definite and immediate adoption. The fact that these trials have not been made on a sufficient scale may perhaps be due to the world economic crisis, as the adoption of such methods would involve the administrations into increased capital expenditure.

2. Only a very small number of railway administrations have adopted definitely and generally mechanical methods of permanent way maintenance and renewal. The time that has elapsed since the introduction of these methods is too short for the results to be considered as definitive.

3. We may note that maintenance work is usually carried out by the railway administration itself, while re-

newal work is done by contract; this must not however be taken as the general rule.

4. Among the operations successfully performed by mechanical appliances, we may note the following :

a) Transport of staff and material by trolleys;
b) Transport of ballast in special wagons;
c) Screwing screw spikes;
d) Tamping sleepers;
e) Screwing fishbolt nuts;
f) Sifting and grading ballast;
g) Adzing and boring sleepers;
h) Weeding.

5. Very few of the administrations have supplied any information on the economic side of the question; it is therefore impossible to establish concrete conclusions by comparing the net costs of the mechanical and manual methods. It is to be hoped that in the future the administrations making such trials will continue to furnish details and make comparisons in order to enable this problem to be solved.

6. It should be noted that the only administrations who have supplied information on the economic side of the question with any degree of completeness are the North American Railways. The high cost of labour in the United States is a particular circumstance which makes it difficult to compare the cost with the corresponding figures for other countries, especially of Europe. Consequently the results obtained cannot be applied to other countries, European or others, as if they were the fruit of more extended trials, because the same set of circumstances does not exist in the various countries.

7. It must not be forgotten that these investigations have been made during a period when the whole world finds its economic structure upset; the result is a wide variation in prices and conditions of life in each country. It is therefore difficult to compare the results, the more so if we take into account the fact that the attitude and conduct of certain countries has been heavily influenced by political considerations which have prevented the railways from dismissing large numbers of workmen, which would have aggravated still more the problem of unemployment. In some cases official pressure has even obliged them to increase the number of their workmen.

8. In view of all this, this interesting investigation should not be considered as completed. The subject of this question should therefore be kept before future Congresses, acknowledging at the same time that much new information has become available since 1930.

[621. 125 (01, 625. 14 (01 & 625, 22]

QUESTION III:

The relationship between the vehicle and the track, to ensure safety at high speeds,

By Messrs. DESPRETS and CHANTRELL,
Special Reporters.

This question was made the subject of three reports :

Report No. 1 (America, Great Britain, its Dominions and Colonies, China and Japan), by Messrs. MATSUNAWA, KUROKOCHI and ASAKURA (1) ;

Report No. 2 (all countries except America, Great Britain, its Dominions and Colonies, China, Japan, Germany, Denmark, Finland, Norway, Spain, Netherlands, Portugal and their Colonies, Sweden and Switzerland), by Mr. DEYL (2) ;

Report No. 3 (Germany, Denmark, Finland, Norway, Spain, Netherlands, Portugal and their Colonies, Sweden and Switzerland), by Messrs. BAUMANN and JAEHN (3).

Each of these three reports consists of two parts; the first dealing with the vehicle, the second with the track.

A. — THE VEHICLE.

Weight of vehicles per axle, position of the centre of gravity, wheel arrangement, layout to facilitate running through curves.

In considering the question of rolling stock for running at high speeds, it is necessary to analyse a considerable amount of statistical data. In this connection, the three reports contain very interesting tables which form a valuable documentation on the subject. Having regard, however, to the diversity in the working conditions, the track gauge, the loading gauge, etc., it would be very difficult to extract therefrom general statistics applicable to railways as a whole.

We will limit ourselves under these conditions to emphasising very briefly the most interesting findings, up-to-date ideas or tendencies, whilst more particularly drawing attention to the personal research work and contributions of the reporters which, without question, have resulted in a notable advance in matters relating to the stability of rolling stock at high speeds.

* * *

High speed *steam locomotives* are almost exclusively built with a leading 4-wheeled bogie. Some cases of bogies with 2 carrying wheels and 2 driving wheels of the Krauss-Helmholtz or « Italian » types are reported; in Italy the tendency for high speed is, however, to return to the standard type of bogie.

The bissel truck is seldom used as a leading truck for locomotives hauling express trains. Several isolated cases have been reported but without any information as to the speeds attained.

With regard to *electric locomotives* which must have equally good running qualities in both directions of running, the 4-wheeled bogie is not so general as on steam locomotives. The reason is that, for the same continuous horse power, the weight of an electric locomotive is less than that of a steam locomotive and thus can have fewer axles.

(1) See *Bulletin of the Railway Congress*, June 1932, p. 1045.

(2) See *Bulletin of the Railway Congress*, November 1932, p. 2141.

(3) See *Bulletin of the Railway Congress*, December 1932, p. 2251.

Consequently a bissel or two-wheeled truck is sometimes used for both directions of running or a bogie for one direction and a bissel for the other, or alternatively two driving bogies which are then often spring-interconnected. Bissel trucks are always fitted with sufficiently powerful controlling gear. Instances are also reported of bogies consisting of one carrying pair of wheels and one coupled pair of wheels (Krauss-Helmholtz, Buchli or « Java », Zara or « Italian » types).

Carriages for high speeds are generally fitted with bogies. A common type of bogie is the four-wheeled with triple suspension having the bolster springs arranged transversely, the type with longitudinal bolster springs being a relatively recent innovation (e. g. Görlitz bogie used on the German State Railways).

The American type of bogie with double suspension is still much used, but through a judicious rearrangement of the equalising beams the relatively small wheel base originally used has been increased.

The six-wheeled bogie is seldom found.

Four or six-wheeled carriages are now comparatively rarely used in express trains; practically only long wheel base carriages of these types with radial axles at each end and a relatively high axle load are allowed to be run in such service.

* * *

A long *rigid wheel base* is particularly favourable for good running of the locomotive on the straight. The length is limited owing to the necessity of running through points and crossings and through curves but it is advisable to make it as long as possible in order to obtain smooth running on straight lengths of track and to reduce the striking angles when hunting takes places.

The *guided length* or distance between pairs of wheels or bogie centres, etc., which influences the posiion of the longitudinal centre line of the locomotive relatively to that of the track, constitutes a factor of capital importance in the value of the guiding reaction on the guiding wheel. The longer the guided length relatively to the rigid wheel base, the more this reaction is reduced, thereby ensuring greater safety in running.

More particularly in the case of the electric locomotives the rigid wheel base is sometimes considerable and sometimes properly speaking there is no rigid wheelbase such as in certain locomotives of the 1 Do 1 type on the German State Railways, having at each extremity Krauss-Helmholtz bogies, the two intermediate pairs of wheels having a certain amount of lateral play. The notion of the guided length and consequently of its relation to the rigid wheelbase is thus not so clearly defined as in the case of steam locomotives.

* * *

Generally speaking, the *loads* on the driving or coupled axles of a steam or an electric locomotive are the same. The loads on the axles of the leading bogies of steam locomotives are considerably less (from 20 % to 40 %) than those on the driving and coupled axles. If it is advisable that this load be sufficient to ensure a good guiding action; the adhesive weight, on the other hand, must not be decreased.

The load on the trailing carrying axles is usually slightly less than that on the coupled axles.

The loads on the two-wheeled truck axles of steam and electric locomotives may be as much as 22 % less than the loads on the coupled axles.

In the case of the tenders, the coal and water carried should be so disposed that the relative loads on the different axles change as little as possible as the quantities carried vary.

* * *

A *high centre of gravity of the locomotive* results in smooth running. The particulars supplied shew that the question of safety against overturning has been satisfactorily solved everywhere.

It should be noted that for steam locomotives the builder has not the opportunity to make such modification in the height of the centre of gravity of a given type of locomotive. The speed restrictions and the construction of the permanent way are therefore the conditions which ought to guarantee the safety of the locomotive against overturning, when running through curves.

The report of Messrs, Baumann and Jachn gives empirical ratios between the height of the centre of gravity of the whole locomotive or the height of the centre of gravity of the spring borne masses, on the one hand, and the height of the centre of the boiler on the other. These ratios agree approximately with practice.

The same report gives a formula for the degree of stability as a function of the height of the centre of gravity, the radius of the curve, the allowed speed, and the degree of superelevation.

Messrs. Matsunawa, Kurokochi and Asakura have examined the influence of the track gauge. They state that the ratio of the height of the centre of gravity to the gauge can be used to indicate the degree of safety against overturning.

They estimate that this ratio should not exceed 1.5 to 1, this figure being reached on the Japanese Government Railways with a gauge of 1.067 m. (3 ft. 6 in.).

* * *

Steam locomotives have 3, 4, 5 or 6 points of suspension, these being in 2 or 3 supporting planes. Three-point suspension is relatively frequently used.

One type of locomotive has 7 points of suspension (Paris, Lyons and Mediterranean — Algerian System, 4-6-0 type), and the French Est Railway locomotive No. 241000, with 4 pairs of coupled wheels, has all its wheels independently sprung and thus has 11 points of suspension.

The bogies of steam locomotives are fitted with either 2 side bearings or one central bearing : they are carried on either 4 independent bearing springs (spherical bearings) or 2 longitudinal springs forming equalisers or 4 springs coupled by longitudinal equalisers (flat bearings).

Electric locomotives show many variations in the method of suspension, which is generally on 3, 4, 6 or 8 points in 2, 3 or 4 planes.

The carrying bogies of electric locomotives most often are fitted with 2 side bearings. In certain cases the leading carrying axle of the bogie is fitted with a cross equaliser which balances the load on the 2 wheels.

The *lateral displacement of steam locomotive* bogies depends on the number of coupled wheels. For example it varies for different types of locomotives as follows :

4-6-0 type, from 38 mm to 80 mm. (1 1/2 in. to 3 5/32 in.);

4-6-2 type, from 45 mm. to 83 mm. (1 49/64 in. to 3 17/64 in.);

4-8-2 type, from 100 mm. to 125 mm. (3 15/16 in. to 4 29/32 in.).

The trailing carrying axles generally have *lateral displacement* which in 4-6-2 locomotives may be as much as 80 mm. to 90 mm. (3 5/32 in. to 3 35/64 in.). Coupled axles rarely have any side play. This refers in general to the last or second last coupled axles of locomotives with 3 or 4 pairs of coupled wheels.

For *electric locomotives* with carrying bogies or two-wheeled trucks the play of the bogies varies from 35 mm. to 150 mm. (1 3/8 in. to 6 in.). The driving and coupled wheels are often given some side play.

The flanges of the leading or of the second coupled pair of wheels, some-

times of both, *are reduced* in thickness on most steam locomotives with 4-wheeled bogies. The reduction in thickness varies from 5 mm. to 15 mm. (25/128 in. to 19/32 in.), and sometimes is as much as 19.5 mm. (49/64 in.), (French Nord Railway). The 4-6-2 and 4-8-2 locomotives of the French Est Railway have the bogie wheel flanges thickened by 5 mm. (25/128 in.), to a thickness of 37.5 mm. (1 15/32 in.). In the 4-8-2 (series 241000) locomotive, the flanges of the 4 pairs of coupled wheels are reduced in thickness by 12.3 mm., 6.8 mm., 6.8 mm. and 1 mm. (1/2 in., 1/4 in., 1/4 in. and 5/128 in.) respectively with a bogie side play of 125 mm. (4 29/32 in.) and on the trailing truck of 150 mm. (6 in.). This locomotive can negotiate curves of 100 m. (5 chains) radius, despite its rigid wheelbase of 6.15 m. (20 ft. 2 1/8 in.).

* * *

The *controlling gear fitted on steam locomotive bogies* operates by springs or by gravity; no very marked preference for either one or other of these types is shown.

In each of these two types there are some designs without initial centring force and others with a certain initial force. The former design is no longer used on new locomotives. Finally certain of the arrangements using gravity have a constant centring force.

It is generally admitted that the initial centring force must be sufficiently high and that its value should not greatly differ from the final one.

The method making use of gravity appears to be general in the United States, Canada and Japan, with a growing tendency to make the centring force constant.

Devices incorporating laminated springs appear to be the most used of the spring controlling gears.

The arrangement of inclined planes is only met with exceptionally (Paris, Lyons and Mediterranean Railway).

The *controlling gears provided on electric locomotives* are also very varied. Locomotives with two driving bogies are elastically coupled together.

Leading bogies, leading carrying pairs of wheels or trailing carrying pairs of wheels are generally fitted with controlling gear with laminated or helical springs.

A controlling gear incorporating helical surfaces is used exceptionally (Paris, Lyons and Mediterranean Railway).

In certain instances in which the bogie has been given considerable side play, controlling gears of special types have been provided (e. g. the Winterthur type on the Paris-Orleans and the North of Spain Railways), these showing the efforts made by builders to find a suitable proportion between the initial and final centring forces.

* * *

As regards the *adaptation of the running gear to irregular surfaces of superelevation inclines* and to the inequalities of the track we would specially point out a very interesting contribution by Messrs. Baumann and Jaehn.

From the static point of view, safe guiding is guaranteed if the guiding wheel remains suitably loaded, if the striking angles are of sufficiently low value, and if there are no exceptional irregularities in the track likely to set up large dynamic forces.

Messrs. Baumann and Jaehn have studied the problem of the relations between the variations of pressure of the guiding wheels and the method of suspension of the locomotives and bogies, and noted that the most unfavourable conditions as regards the unloading of the guiding wheels occurred when leaving a superelevated curve and entering the superelevation incline. Each method of suspension can be defined by a *support characteristic* which is repre-

sentative of the static properties of the suspension and which depends upon the relative flexibility of the springs of the main frame and those of the bogie.

The values of the support characteristic for the case of the leading pair of wheels of the bogie, when entering the superelevation incline, have been calculated for different methods of suspension and plotted graphically as a function of a ratio which characterises the position of the bearing springs relatively to the sole bars. Further, for each method of suspension, support characteristic curves have been plotted for various values of the ratio of the flexibility of the main frame springs to that of the bogie springs.

The conclusions from this investigation can be summarised as follows : in order to guarantee a sufficient static load on the guiding wheels entering a superelevation incline after leaving a curve it is recommended to adopt the suspension in two traverse planes for locomotives, i. e. on 3 or 4 points. If 5-point suspension is necessary the preference should be given to having a central spherical bearing on the bogie.

* * *

The general opinion is that the *guiding of the locomotive* should be through the bogie centre pin only, without intervention of the first pair of wheels in the frame as otherwise these wheels would be subject to side shocks which are particularly injurious in the case of a crank axle.

It is, however, not always possible to avoid the first pair of wheels taking part in the guiding. To reduce this participation, the French Est Railway has, in certain cases, increased the thickness of the bogie wheel flanges from 32.5 mm. to 37.5 mm. (1 9/32 in. to 1 25/32 in.).

* * *

Security against derailment has up to the present been expressed by a classic formula in which the ratio between the transverse reaction Y of the rail on the flange and the vertical load Q on the wheel must not exceed a certain value, a function of the coefficient of friction μ and of the angle α of the face of the flange.

Recent researches by the German Railway Association (Verein) have enabled a new formula to be evolved giving the maximum admissible value of the ratio in question not only as a function of μ and of α, but also including the diameter of the wheel as well as other factors, determining the striking angle.

The value of the ratio $\frac{Y}{Q}$ obtained for wheels of different diameters and for contact angles up to 2° have been plotted graphically and shew that the security against derailment is very high with small striking angles. As the contact angle increases the security against derailment diminishes rapidly at first, then decreases slowly for large contact angles (1° to 2°) and approaches asymptotely the value

$$\frac{1}{\mu + \text{cotan } \alpha}$$

We can therefore infer that a large wheel diameter, a large striking angle and a high coefficient of friction decrease the security against derailment while a high value for the angle of the face of the flange increases this security. Nevertheless flange angles exceeding 60° are scarcely used; wheels with flanges having a greater angle result in more rapid rail and wheel wear and further considerably increase the resistance on curves.

Recent researches have shown that the angle of the side face of the flange may be made under 60°, thereby reducing wear, without decreasing the security against derailment. Trials are being made on the German State Railways with flanges at an angle of 54°.

Various schemes of *flange lubrication*

have been adopted in order to decrease the coefficient of friction between the flange and the rail and thereby improve the safety; the rails on small radius curves are more rarely lubricated.

The problem does not appear to have been solved everywhere in an entirely satisfactory manner; it is desirable that this question should receive an efficient and practical solution.

The Japanese State Railways have adopted the method of the continuous spraying of the rails by water from the tender, the water being delivered immediately in front of the first pair of coupled wheels.

The consumption of water is only 280 litres (62 Br. gallons) per hour. The results appear to be very satisfactory.

* * *

The above considerations only deal with the question of security against derailment from the static point of view.

Messrs. Baumann and Jaehn quote the recent investigations of Mr. Dauner and of Mr. Uebelacker relating to the *dynamic effects* caused through the guiding wheels suddenly coming into contact at an oblique angle with the rails, as well as the trials which are now being made on the German State Railways to determine the wheel loads and the guiding forces as they are actually found on the moving vehicle.

Mr. Deyl instances tests made by the Paris-Orleans Railway on an Oerlikon electric locomotive with the same object in view.

This Company considers it will be possible to reduce the dynamic forces by abolishing the gauge widening on curves in order to decrease the jarring of the leading wheels against the rail, especially at the moment of entering the curve.

The same reporters point out that careful trials are taking place on several railways for determining the lateral oscillations of the bodies of carriages at high speeds, and that interesting results are expected therefrom.

In steam locomotives the *reciprocating masses are partly balanced* by counterbalance weights. However, in certain types of 4 or 3-cylinder simple expansion locomotives this counterbalancing has been abandoned.

In general on locomotives with part of the reciprocating masses balanced, the counterbalance weights are calculated so that, at the highest train speed, the centrifugal force will not in any case exceed 15 % of the static load per wheel.

* * *

Most railways have introduced certain *limits of wear* for both locomotive wheel tyre flanges and treads before turning is necessary.

A minimum thickness limit varying from 30 mm. to 43 mm. (1 3/16 in. to 1 11/16 in.) is laid down at which tyres are withdrawn from service.

The Japanese State Railways have adopted a special rule for sharp flanges. When the distance as measured along the wheel diameter is less than 1.5 mm (0.059 inch) from the sharp point to the extremity of the flange it must be withdrawn from service. The same is done if this distance being less than 3 mm. (0.118 inch), the angle between the worn part which has become straight and the inside flat surface of the wheel is less than 17°. These limits have been established after examining 163 profiles of flanges the shape of which was considered as having been the cause of derailments.

Summary.

The above considerations enable the following statements and summary to be made :

1. For high-speed steam locomotives,

guiding by four-wheeled carrying bogies is found to be the general practice. Two-wheeled trucks are more rarely used.

High-speed electric locomotives have four-wheeled carrying bogies, or bogies with 2 carrying wheels and two driving wheels, or two-wheeled trucks, or a bogie for one direction of running and a two-wheeled truck for the other, or again two driving bogies.

It is recommended that the vehicle should be guided by the bogie centre pin only, that a long rigid wheel base be provided with as long a guided length as possible.

1. Carriages for high speeds are preferably bogie vehicles. There is a marked tendency towards the use of long wheel base bogies.

3. A high centre of gravity of the locomotive is an advantage as regards smooth riding. The question of security against the locomotive overturning has been satisfactorily solved everywhere.

4. Generally speaking locomotive bogies are provided either with gravity or spring controlling gear. The initial centring force should be sufficiently high and not differ greatly in value from that of the final centring force.

5. Among the various methods of suspension for locomotives, the arrangement in 2 transverse planes, with the engine supported on 3 or 4 points, most satisfactorily ensures that there is sufficient static load on the guiding wheels when entering a superelevation incline on leaving a curve.

6. Security against derailment decreases as the diameter of the guiding wheel, the striking angle, and the coefficient of friction, increase; on the other hand a high value for the angle made by the outer face of the wheel flange with the horizontal increases the security. The value of this angle is however limited by the following considerations : *a*) more rapid wheel flange and rail wear; *b*) increased resistance on curves.

In order to reduce the coefficient of friction, it is desirable that some efficient and practical solution be found of the question of lubricating wheel flanges when running through curves.

7. Research work and trials, the results of which will possibly be communicated to the Congress are now being carried out on several railway systems on the investigation of the dynamic forces caused by the violent impact of the guiding wheels of locomotives with the rails and also on the determination of the lateral oscillations of carriage bodies at high speeds.

B. — THE TRACK

Strength of the track, widening of gauge, radius of curves, superelevation, transition curves, points and crossings, check rails.

The reports submitted show in detail, based on the replies to the questionnaire received from the railways, the various points dealt with :

Strength of the track.
Gauge widening on curves.
Radius of curves.
Superelevation.
Transition curves.
Points and crossings.
Check rails.

It could hardly be said that many really new data have been put forward.

All the reporters are unanimous in their conclusions that for high-speed running on the straight, the track requires to be strong and carried on a firm foundation, with long heavy rails on closely spaced sleepers, the joints carried on twin or closely set sleepers, with a formation of thick well-drained ballast, etc.

Track calculations have not made much progress : besides it is doubtful whether such calculations could really be useful.

It must, however, be noted that the

problem is especially a dynamic one and thus very complex and difficult to solve.

To suppose that it were possible to limit ourselves, even from the static point of view, to considering only the influence of a single pair of wheels would be entirely erroneous. On the other hand the consideration of sets of pairs of wheels introduces, especially in dynamic phenomena, insurmountable difficulties.

The much simpler problem of the dynamic forces in metal railway bridges is a sufficiently clear indication of the difficulties of the calculations.

We should like to call attention to the experimental trials on the dynamic deformations of the track carried out in Japan and the United States.

The question of gauge widening in curves and on the straight is going through a peculiar evolution. At present the tendency is to decrease it, as much, we believe, to ensure closer guiding of the vehicles, as to increase the allowable rolling stock building gauge.

The questions relating to radii of curves, superelevation in curves and transition curves are intimately connected.

Everyone agrees and recognises that curves must be so laid out that a reduction of the speed from that allowed on the straight is unnecessary. For this, the curves must have a sufficiently large radius, the necessary superelevation, and transition curves with continually varying curvature and a longitudinal profile with very easy gradients.

It is necessary to ensure absolute safety in service for locomotives with high centres of gravity, running at high speeds, that vehicles may run without undue parasitic movements, irritating to the passengers, and on the other hand, that the wear of the track shall be regular and as equal as possible in the different parts.

The regulations in force on different railways to arrive at these results, differ.

We ought to point out, in particular, that certain railways do not consider it necessary to balance completely the centrifugal force. A new rule limiting the free centrifugal acceleration tends to become the measure of safety at the maximum running speed.

The question of turnouts on main lines has been the subject of important chapters in some of the reports.

Here again opinion is unanimous in recommending that no speed limit should be enforced at turnouts.

Among the methods suggested with this object in view, we may mention the diminution or elimination of the angle of deviation of the tongue, the laying of the turnout to a large radius, the curve being carried into the crossing, careful placing of the check rail, the laying of the points and crossings on a slope, etc. This question by itself merits further detailed investigation at some future Congress.

The use of check rails has been dealt with in all the reports. As a general conclusion, guard rails are recommended in certain cases, particularly on long bridges.

Some of the particular points in the different reports presented are given below.

* * *

The report of Messrs. Matsumawa, Kurokochi, and Asakura is particularly interesting on the subject of the strength of the track and the electrical apparatus used for measuring rail deformation.

They propound. for example, a practical formula for determining the weight of the rails. This weight should equal, in kilogrammes per metre, 2.5 times the axle load in tons.

The report of Mr. Deyl is an elaborate statement on the subjects included in the questionnaire. It is very detailed and includes much interesting data. We would particularly mention the chapter relating to the running of vehicles

through curves as this appears to be a special contribution on the part of the author.

The report of Mr. Jaehn is an abridged and well informed review of all matters affecting the modern track, superelevation, transition curves, and turnouts run over at speed.

The part dealing with superelevation and transition curves appears to us to merit special mention. We would specially call attention to the formula suggested for the superelevation :

$$h = 8\frac{V2}{R} + 30$$

and for the inclination of the parabolic curve as a function of the speed :

$$\frac{1}{n} \leqslant \frac{1}{10\,V}.$$

Taken together, these three reports form a detailed and complete review of the main questions of interest relating to modern track and its ability to carry heavy loads at high speeds.

The reporters have very conscientiously completed a difficult, laborious and synthetical work on the varied data submitted.

The reports constitute a new and invaluable documentation on the subject and will be consulted with profit by all permanent way engineers.

* * *

In view of the large number of points under review it would be difficult to give a brief resumé on all the subjects in the questionnaire and still more to set out any summaries applicable to all railways.

We propose to limit ourselves to commenting in a general way on certain subjects of particular interest.

1. The calculation of the strength of the railway track is especially a practical matter.

The experimental research work undertaken by certain railways ought, however, to be encouraged and followed with interest.

Special attention should be paid to all trials tending to the elimination of rail joints — the use of long rails, the welding of rails, etc.

2. The present tendency is to diminish gauge widening and to ensure closer guiding of the vehicles by the track. Systematic trials, with this object in view, ought to be pursued.

3. The rules used for determining the speed through curves, the superelevations and the transition curves between circular curves vary on the different railways. These factors, which affect high-speed running through curves, could usefully be made the subject of further research work, which would take into account the forces called into play when the vehicles are running.

4. Turnouts on high-speed tracks should be so laid out that no speed restriction will be imposed when they are run over.

SECTION II. — Locomotives and Rolling Stock.

[621 .138]

QUESTION IV:

Methods to be used to increase the mileage run by locomotives between two repairs including lifting,

by Sir Henry FOWLER, K. B. E.,
Special Reporter.

The object of this special report is to place concisely before those attending the meetings of the Congress, the main points from the three individual reports (1) on question IV. It is not proposed to discuss the reasons for the statements which have been made. At the end of the special report a summary will be drawn up, and it is hoped that this may form a basis for the discussion of the question.

The object of the three questionnaires, which are practically identical, was to ascertain what steps have been, and are being, taken to obtain as great a mileage as possible between two heavy repairs.

General or heavy repairs.

It is first necessary to ascertain the principal cause or causes that make a heavy repair necessary.

M. Klatovsky states that the most usual cause of *lifting* is the necessity for turning the wheels and attending to the bearings. It is evident, however, from the replies received in this report, as well as in the two others, that the chief reason for a *heavy repair* is the condition of the boiler. As Dr. Student's report points out, the wheels of a locomotive may require re-turning once or even twice between two heavy repairs.

It is interesting to note that the Eastern Railway of France makes special arrangements for their express locomotives to be repaired between October 1st and May 1st, so as to be in perfect condition during the summer, when the greatest number of such locomotives are required for service. It is probable that requirements such as these account for the great variations between different railways, in time and mileage given for the period between two heavy repairs.

The time or mileage varies also, naturally, with the class of locomotive being dealt with (passenger, goods, or shunting). In some cases, with passenger locomotives, the period between two heavy repairs reaches 200 000 miles, and with certain new German express engines, even higher than this. It will be appreciated that, as far as the boiler is concerned, time as well as mileage is an important factor.

In certain countries legislative regulations exist, calling for a periodical examination of the boiler. This is usually on a time basis, but in the Argentine Republic it is depended upon the mileage run.

Intermediate repairs, and examinations between general or heavy repairs.

As the three reporters did not agree on an identical questionnaire, these two sections must be taken together. Un-

(1) Report No. 1, by Sir Henry FOWLER, *Bulletin of the Railway Congress*, April 1932, p. 287.

Report No. 2, by E. STUDENT, *Bulletin of the Railway Congress*, June 1932, p. 983.

Report No. 3, by R. KLATOVSKY, *Bulletin of the Railway Congress*, August 1932, p. 1539.

doubtedly, where systematic efforts are made to get the greatest possible mileage, between heavy repairs, locomotives must receive attention in several respects between these thorough overhauls. The greater part of the work which has to be carried out is caused by the wear of the tyres. This is generally dealt with by re-turning the tyres, but in certain cases pairs of identical axles and wheels are interchanged under the locomotive. The axleboxes and bearings and certain other parts also receive attention. The time occupied in carrying out this work may amount to as much as 15 days. A striking example of how the work may be done extremely expeditiously is seen in the United States of America, where, by law, the boiler must be washed out each month irrespective of the quality of water, and certain other inspections must be made. This entails a certain time each month during which the locomotive is not available for service. The opportunity is, therefore, taken for carrying out certain repairs during this time, and arrangements are made in many cases for the engine to be worked upon during every hour of the day and night that it is out of service.

The general opinion of the Administrations is that intermediate repairs lead to a decided and considerable increase of mileage between heavy repairs. The same may be said with regard to the systematic examination of various parts. It is also found that these latter precautions tend to eliminate casualties, and not only prevent breakdown, but also allow more mileage to be run in a given time.

Materials, Design, etc.

The hardness of the tyres and the rails has an effect on the mileage run between heavy repairs. It is generally considered that the tyre should be somewhat harder than the rail. On the Continent of Europe, the tyres have a hardness varying from 44.4 to 58.4 tons per square inch. In Great Britain, although the tensile strength does not usually exceed 62 tons per square inch, there is, nevertheless, a standard tyre having a tensile figure up to 69 tons per square inch, and tyres of about the latter strength are also used on certain railways in the United States of America and in the British Dominions. In only one case (Canadian Pacific Railway) are alloy steel tyres specified, and these are of 3 % nickel steel, having a tensile strength up to 78.1 tons per square inch.

It is generally agreed that harder tyres give greater mileage, but, except in one or two cases, the relation of the contour of the tyre and rail has not been studied. It is claimed by some railways that a double inclination on the tread of the tyre leads to longer service, but one or two lines think that this prevents sufficient adhesion.

Lubrication of tyre flanges, or of the sides of the rails on curves, is practised by some railways, more particularly in the United States of America; but elsewhere it is not general, although many trials are being made, and the practice is in use on certain lines under special conditions.

There seems to be a tendency towards an increased use of cast iron as a packing material for glands.

The importance of using water of good quality is appreciated, as bad water increases the boiler maintenance, and may materially affect the mileage between heavy repairs.

The employment of mechanical methods of lubrication seems to be increasing. In the United States of America and in Canada, grease is generally used for axleboxes, etc., and this practice seems to be increasing in hot climates.

Operation.

Generally there is an opinion that pooling or multiple manning of loco-

motives has a detrimental effect on engine maintenance, but is beneficial with regard to daily mileage, and mileage covered between heavy repairs. Mr. Klatovsky's report is the only one which states that a single set of men is employed, in the majority of cases, on passenger and goods locomotives. The railways covered by the other reporters generally use pooling or multiple manning. On nearly all railways, two or three sets of men are employed with shunting engines.

In North America and also in the Argentine Republic, many locomotives run well over 400 miles a day. On the New York Central Railroad, passenger locomotives operate up to 657 miles and freight locomotives to 800 miles per day. One Indian Railway has experimented with a run of 562 miles, using triple crews.

The length of non-stop runs has increased; the London & North Eastern Railway of Great Britain has one of 393 miles with a double crew on a passenger train, while the London Midland & Scottish Railway has one of 301 miles with a passenger train, and one of 191 miles with a freight train. There is no doubt that these long runs, with a single firing up of the locomotive, are conducive to good mileage between shoppings.

Dr. Student points out that good boiler design also contributes to this, and states that the boiler portion of the engine should only be worked to 60-70 % of its capacity.

The German State Railways pay a premium to engine crews for mileage between shoppings in excess of a fixed basis figure for the particular type of engine.

General.

Many interesting points have been raised in the replies received from the Administrations, when dealing with the various steps which have been, or should be, taken to increase the mileage between heavy repairs.

It is pointed out that good fuel should be used wherever possible, as this leads to less wear on the boiler. The constant improvement in boiler and engine design also naturally helps in increasing the mileage. The Baltimore and Ohio Railroad of America hopes that the experiments which they (and some other railways) are carrying out with boilers incorporating water tubes, will lead to a reduction in boiler troubles generally. Increased attention to the water used, and improved means of washing out boilers are both desirable; boiler washing appliances and boiler design both contribute to the latter end. The German State Railways deprecate chemicals, etc., added to the boiler to remove scale, but strongly advocate mechanical « mud removers ». The employment of special material for certain parts where wear takes place, helps considerably.

The general speeding up of repairs, although it does not increase the mileage between such repairs, allows of a greater mileage in a given time. The total mileage run between heavy repairs is materially improved by increasing the daily mileage, though, when locomotives are pooled or operated by mixed crews, the repairs costs are inclined to be higher; this point requires to be carefully watched. It is undoubtedly a good thing for a boiler to be kept in service as long as possible, at one time, without drawing the fire. The German State Railways have found that the payment of a bonus to drivers and firemen for extra mileage between heavy repairs has increased the mileage by 55 % on the average, and in certain cases by 200 to 300 %. Various other methods are also mentioned in the reports to get an increased mileage from locomotives.

Two of the three reports mention the advantages which accrue from having locomotives which are large enough to

be worked at only a percentage of their actual maximum capacity.

Dr. Student lays great emphasis on the importance of having good main shops, with accurate machines and good workmanship, and says that the extra cost will be easily repaid by the extra mileage obtained between heavy repairs. With reference to shed repairs, he states that it is preferable to employ a few too many men, rather than too few.

SUMMARY.

1. One of the chief reasons for locomotives requiring heavy repairs is the attention which has to be given periodically to the boiler. It is, therefore, obvious that boiler design is of primary importance, and arrangements should be made for it to receive suitable water, and for it to be washed out properly.

2. Regular and systematic examinations tend to the discovery of defects, and the renewal of worn parts, and so prevent casualties, and loss of mileage.

3. Tyres usually require to be re-turned between heavy repairs, and, therefore, every attention should be given to providing material which will give as little wear as possible. The study of the relation of the wear of tyres and rails merits more attention than has so far been given to it.

4. An intermediate repair, where tyres, bearings, etc., receive attention, can be quickly carried out if systematically performed, and materially increases the mileage between heavy repairs.

5. There has been a tendency in recent years to obtain a greater mileage per day from locomotives by various means; this is an advantage in itself, and also tends to increase the total mileage between heavy repairs.

6. Where it is possible, and the permanent way and loading gauge allow, it is an advantage to employ locomotives which are ordinarily worked well below their maximum capacity. The increased capital cost, however, must be borne in mind.

[621. 33]

QUESTION V :

Electrification of railways from an economic point of view. Selection of sites for generating stations. Choice of the kind of current. Safety precautions, etc.,

by Mr. JAPIOT,
Special Reporter.

Question V was made the subject of three reports :

Report No. 1 (America, Great Britain, its Dominions and Colonies, China and Japan), by Mr. S. WITHINGTON (1);

Report No. 2 (Belgium, Spain, France, Italy, Holland, Portugal and their Colonies, Denmark, Finland, Luxemburg, Norway and Sweden), by Messrs. JAPIOT und LEBOUCHER (2);

Report No. 3 (all other countries), by Dr. E. HUBER-STOCKAR and Mr. H. ECKERT (3).

Although the reporters sent the same questionnaire drawn up in agreement between themselves, to all the Administrations concerned, it was not possible to present the three reports in an identical manner even to details. The close resemblance of the texts shows, however, that this feature is due rather to the great difference in character of the replies received than to the point of view of each reporter. It would, moreover, be difficult for this to be otherwise as each Administration dealing with the problem from the point of view of the conditions peculiar to its undertaking, naturally had to attribute to the various aspects thereof a varying relative importance.

If the three reports differ in form, on the other hand it is found that there is *no divergency of opinion fundamentally*. This agreement between the reporters has greatly facilitated our task, as, in spite of having to co-ordinate the three reports whilst avoiding the methods of presenting the matter adopted by one or other reporter, we found no difficulty in faithfully summing up the essential parts, and in bringing out the conclusions common thereto.

(1) See *Bulletin of the Railway Congress*, April 1932, p. 379.

(2) See *Bulletin of the Railway Congress*, September 1932, p. 1717.

(3) See *Bulletin of the Railway Congress*, June 1932, p. 857.

PART I.

Electrification of railways from an economic point of view.

I. — Generalities.

Electrification may either be the substitution of electric traction for steam traction on a line already in operation, or the adoption of electric traction instead of steam traction on a new line to be built or under construction.

Safe in exceptional cases, electrification of this sort involves a large additional capital investment and consequently involves a *heavy increase in capital charges.*

It is on the other hand capable of procuring *appreciable savings on the working expenses.*

The change-over can therefore be considered an *economy in itself* if the increase in capital charges is definitely covered by operating economies.

Electrification, moreover, brings with it *indirect advantages* of such importance that in some cases they are the decisive factor in the adoption of electric traction.

In order to consider an electrification from the economic point of view, it is therefore necessary to include in the comparative balance sheet for electric and steam traction not only the capital charges and the operating costs but also the indirect advantages which may be translated into figures.

It is clear, however, that in order to deal with the question actually submitted to the Congress we can take only note of such indirect advantages as are of an *economic kind*; it is indispensable to note, however, that many electrifications have been or can be justified by considerations of quite another kind, and the fact that some of these are not within the scope of the present study should not lead to their value being in any way underestimated.

Before examining the different sections of the financial balance sheet of an electrification it is as well to point out the *difficulties* met with in getting it out with sufficient accuracy.

Even in the case of a method of operation actually in force it requires fine judgment, with rare exceptions, to separate from the accounts of a company the partial expenditures relating to a given line ; most frequently it is only possible to do so by abstracting the value of the different details, which involves hypotheses, even possibly some arbitrary assumption.

It is still much more difficult to determine the expenditure due to the hypothetical method of operation that is to be compared with the method in use.

If, for example, it is a question of investigating the electrification of a steam-operated line, the relative information on electric traction can only be obtained from neighbouring lines, the conditions on which may differ more or less considerably from those of the line considered.

If, on the contrary, an attempt is made to compare electric operation with the steam operation it replaced, allowance must be made for the variations which might have taken place in the costs of the latter since the time it was abolished, on the basis of the results obtained on more or less similar lines on which steam traction has been retained.

The comparison is still more problematical in the case of a line to be built, as in this case the data concerning the two methods of traction solely result from comparisons with other lines.

Furthermore, whether it is a case of a line already in operation, or a new line, the two services compared have as a rule very marked differences. The possibilities of electric traction in the way of increasing the loads and the speeds or to give a more frequent service thanks to the use of motor coaches, etc., are made use of. For the comparison to be fair, it would be necessary to calculate the cost of the same service worked by steam, supposing that this was possible ; or, in the contrary case, an electric service equivalent to the steam service should be first of all considered, and then the expected improvements be compared with the increased cost involved. Inversely, it is sometimes thought that the comparison should not bear upon the actual cost of steam traction, but upon what it would become if the stock of locomotives was supposed to be entirely modernised, the cost of this modernisation being, however, taken into account when comparing the capital charges.

The evaluation of the capital charges, moreover, involves other difficulties :

apart from interest upon the capital and their financial amortisation, the *industrial amortisation* of certain parts of the installations or of the rolling stock should be spread over a shorter period owing to wear or simply through obsolescence, and this is where we find the greatest differences in practice in the methods followed by the administrations. Certain companies charge to the operating account the annual payments to a renewal fund; in other cases certain renewal expenditures are included in the maintenance charges as they are expended, whereas any equipment done away with or rolling stock condemned, are charged up to the operating account at the moment they are taken out of service. In addition, even in the case of administrations who agree upon the principle of renewal funds, there are difficulties when it is a case of fixing the rate of these contributions or of deciding if the capitalised interest should be brought to account or not.

From these various considerations we see with what care financial studies of an electrification should be judged, and the value of bringing together information collected for this purpose by the different administrations, provided however, that the method of arriving at the figures given as well as the special conditions which can make the values of certain of them abnormal are made quite clear. It is interesting to mention, as an example, the very valuable information supplied on this subject by the Swiss Federal Railways, and to stress the value of the investigation which is now being carried out by the German Railways in this connection.

II. — Capital charges.

The capital charges are nearly always the most important item in the electrification account.

One of the reporters quotes a definite case in which these charges alone are 65 % of the total expenditure of electric traction, the operating costs only representing 35 % of the same total ; the situation is very different in the case of steam traction in which the operating charges reach on the contrary 91 % of the total, and 9 % only is left for capital charges.

It is easy to understand from this example the decisive consequences on the balance sheet of the *rate of interest* at the period when the electrification takes place; an electrification which, carried out in time of cheap money, shows itself profitable might easily result in a deficit if financed with money at high rates of interest.

These figures also show that it is essential to calculate the capital charges with the greatest *accuracy,* as a mistake under this head might completely upset the balance sheet.

It is therefore desirable in particular to make each expenditure individually at *the actual rate of interest and of amortisation* corresponding to the real conditions of the operations which served or which should serve to finance each work or purchase.

The adoption of an average rate might modify to an appreciable extent the aspect of the problem when the work extends over a period during which the rate of interest alters. The same remark also applies to the case frequently found in certain countries in which the method of financing the purchase of stock differs profoundly from that of electrically equipping the track : there can then be wide variation in the rates of the charges applicable to each of these elements.

After having calculated the interest charges and the financial amortisation of the capital, the additional charges corresponding to the *industrial amortisation* have still to be calculated : we have already called attention to the dif-

ficulties of making this calculation, and the wide differences between the rules followed by the administrations according to their particular financial or administrative arrangements.

It should also be noted that in the concrete case to which the reporter previously quoted refers, where the capital charges represent 65 % of the total expenditures on electric traction, the interest on the capital represents 51 % of this figure against 14 % for the financial and industrial amortisation : in another form, the share of the interest in the capital charges therefore reaches 78.5 % and that of the financial and industrial amortisation only 21.5 %. There is therefore a temptation to conclude that if the financial charges properly speaking are calculated exactly (interest and amortisation of capital) an error in appreciating the method of dealing with the industrial amortisation will not alter too seriously the appearance of the balance sheet.

The calculation of the charges ought naturally to show as *debit* and *credit* the total of the capital *required* or *made unnecessary* by electrification.

On the debit side will obviously be shown the whole of the installations directly required by the electric traction (power stations, high tension lines, substations, contact lines, electrical rail bonds) and also the purchases of rolling stock (locomotives and electric motor coaches).

In addition the whole of the *accessory* expenditure sometimes very heavy, which results from electrification, must also be included.

Thus the installation of the contact lines (overhead wire or third rail) may require the lines in the stations or at certain special points (bridges, tunnels, etc...) to be rearranged, — the displacement or even the putting of the telephone and telegraph lines under ground — alterations to or even the replacement of the signals and signalling circuits — supplementary installations intended to overcome the inductive disturbances if it is a question of alternating current, or electrolysis with continuous currents, etc.

In the case of rolling stock, the expenditure for heating passenger trains in winter, whether by using electric radiators in the carriages, or by purchasing steam-boiler-fitted wagons to ensure steam heating, must also be taken into account.

The electrification should, on the other hand, be *credited* with the capital expenses avoided throught it, and this consideration is sometimes sufficient to change completely the economic aspect of the question.

This is particularly so in the case of a line working at its full capacity, and the growth of traffic over which would require the line to be doubled, either by the addition of new lines, or by the construction of an entirely new parallel line : the cost of the doubling or this new line should be taken as a reduction on the cost of electrification.

In the same order of ideas may be quoted the electrification of lines terminating at a large station, the equipment of which has become unable to deal with the growth of traffic and the cost of enlarging which would be saved thanks to the increased capacity given by electric traction. In addition, as the requirements of the locomotive depots can be reduced, electrification can also make it possible to enlarge the stations without the purchase of new land becoming necessary.

In the case of a new line, the adoption of electric traction enables heavier gradients to be used and consequently a cheaper location to be acceptable ; it makes it unnecessary to install further water columns and reduces the expenditure for sheds and the maintenance of locomotive stock ; all these savings

on the total cost of building the line ought to be taken into account when dealing with the cost of electrification.

The substitution of electric traction for steam traction on an existing line raises a problem of a different kind with regard to *the equipment rendered useless*, whether preserved with a view to subsequent re-utilisation, or whether definitely done away with : such can, for example, be the case with certain installations for the supply of water to the steam engines, or with sheds and repair shops.

It is generally agreed that the charges corresponding to the interest and the *financial* amortisation of the capital invested in these no longer useful or suppressed installations should not be charged to the electrification, because the previous capital expenditure continues without any change : the situation in this respect remains exactly after electrification what it was formerly.

On the other hand, opinions vary considerably as regards the *industrial* amortisation of these installations. It is sometimes considered that electrification should carry the whole of this amortisation, i. e. the difference between the initial capital cost and their residual value. If these installations have been covered by contributions to a renewal fund the charge should only deal with the balance not yet written off.

The question is still more complicated in the case of the *steam locomotives rendered useless by electrification.*

If these locomotives should be written off, the electrification should evidently carry the financial consequences of these, taking into account if need be the existence of any renewal fund.

When the surplus locomotives on the other hand ought to be used again on other lines to meet the actual needs thereof, the electrification should then be credited with the actual value of these locomotives, and in order to arrive at this actual value the price of new locomotives the purchase of which has been saved in this way and on the other hand the fact that locomotives to be used again have already been depreciated to some extent must both be taken into account.

It may also happen that the surplus steam locomotives, though they may not be used again immediately, can be retained in view of future requirements of other lines, owing to the progressive growth of the traffic : it then becomes difficult to decide the value represented by these locomotives to be credited to the electrification, this being on the other hand debited with the capital for the period these machines were out of service.

These observations show that it is rather rare for the part of the balance sheet dealing with the locomotive stock to be a simple comparison of the purchase prices of the electric and steam locomotives required to work the same service.

This simple case is hardly ever met with, except in the case of a line to be built, but certain problems are very close to it. The comparison between an existing electrically operated line and the hypothetical steam operation with an entirely modern stock of machines would have given such a case. In the same way, the electrification of a line equiped with modern steam locomotives which can be used again immediately is very similar to the case previously quoted.

It is therefore interesting to point out that this comparison can be advantageous for electric traction from the financial point of view in spite of the appreciably higher unit prices of the electric locomotives compared to those of steam locomotives able to cover the same service, because the total stock required is

much smaller in the case of electric traction. Moreover the operations of coaling and repairing steam locomotives take much longer. Again the electric locomotives are nearly always pooled, whereas most of the administrations endeavour to avoid doing this in the case of steam locomotives, as a result of which the work done by them daily is reduced.

In practice the difference between the costs of the stocks of locomotives is still much greater because the electric locomotives are generally much more powerful than the steam locomotives and their unit price is far from increasing in proportion to their power.

III. — Working expenses.

The distribution of the working expenses and their grouping under different headings varies naturally frome one administration to another, and this difference is repeated in the reports : a unification of methods cannot be expected on this subject and the essential is to determine in a precise manner all the items of the expenditure to be taken into account in the comparison, whatever the method of grouping used.

For example, the following nomenclature may be adopted :

1. supplies to the locomotives and rail motor coaches whether in electric energy or in fuel and water ;
2. driving the locomotives and motor coaches ;
3. maintenance and lubrication of locomotives and rail motor coaches ;
4. heating passenger trains in winter ;
5. miscellaneous expenditure in the depots ;
6. maintenance of permanent way ;
7. train staff.

The field covered by each of these paragraphs will be made clear by indicating on the one hand the expenditure items to be included and on the other the conditions capable of influencing in one way or another, the financial balance sheet of the electrification; in this investigation we will generally only consider the cases most frequently met in practice; we will also mention a few special cases, and this would make it possible to deal more easily by analogy with the exceptions which might have been overlooked in this analysis.

It is of course understood that each expenditure examined should be considered as affecting not only the gross expenditure directly taken into account, but also the proportion of the general charges falling on it.

1. — *Supplying either electric energy or fuel and water for the locomotives and rail motor coaches.*

In the case of electric traction this paragraph should include all the expenses (materials and labour) affecting the purchase or production of the energy, its transport in the form of high-tension current to the substations, its transformation at the latter, the supervision and the maintenance of the contact lines and installations in connection therewith (sectioning equipment, electrical rail bonding, etc.).

In the case of steam traction the expenses to be dealt with are those relating on the one hand to the purchase of fuel, its transport to the locomotive depots, its handling in the depots until it is loaded onto the tenders and, on the other hand, the water service (including water treatment if used).

It must be noticed, however, that the comparison dealt with in this way is seen in quite a different light according as the railway produces its own current or purchases it ; in the first case the capital invested in the power stations having been dealt with in the previous chapter we have only to deal with the cost of working these power stations ; in the second case, on the contrary, the expenditure for the purchase of current takes into account the capital cost of

the power stations, their working costs and finally the profits on the sale of energy. This energy can even be supplied to the railway company, instead of at the power station, at the substations, in which case the price includes in addition the cost of transport over the high-tension lines (capital charges, supervision and maintenance costs).

It may therefore be considered preferable to compare in all cases the *total cost price* of the fuel delivered on the tender with the total cost price of the electric power at the locomotive. It is then necessary to compare not only the direct expenses enumerated, but to extract from the preceding section, to include them in this section, the capital charges corresponding to the necessary installations, namely : — in the case of steam traction, the wagons set aside for conveying fuel, and liberated by the electrification, as well as the equipment at the depots for handling the coal and loading it on the tenders; — in the case of electric traction, the power stations, the high tension lines, the substations, the contact lines and their equipment.

In some cases, the cost price of the electric energy at the entry to the substations is considered sufficient, as this eliminates the difference between the cases of production and transport by the equipment of the railway company and that of purchasing from a third party, either at the power station or at the substations. Once this calculation has been made, there remains only, to complete this paragraph, to add the cost of supervision and maintenance of the substations, of the contact lines and their equipment, the corresponding capital charges being included in the preceding section, or inserted into the present paragraph according to the custom of each administration.

To sum up, the methods of showing the comparison differ according to the object in view when making the comparison; all that is necessary is that expenditure (capital charges and working expenses) should be covered in one or other of the headings of the balance sheet.

In addition, if the railway produces and transports its own power, there should figure on the *credit* side of this paragraph both the receipts made by the sale of the excess power to third parties by the railway power stations, or by conveying over the high-tension lines of the railway company energy from other power stations for third parties.

So that this section should be as *advantageous as possible* for the electric traction, the cost price of the power should be reduced by all possible means, and also the consumption, the cost of supervision and maintenance of the substations and of the contact lines.

The *cost price of power* varies evidently in appreciable proportions according to the conditions under which the power stations were built and are operated, but it appears advisable to point out the repercussions which the methods adopted by the railway company to obtain power and transport it to the substations may have in this matter.

In the case of an electrification on a small scale in which the average power required is low, whereas the peak loads are relatively heavy, there is generally every advantage in purchasing the energy outside rather than in constructing a special power station, the use of which would be very limited and which would consequently supply current at a prohibitive price.

The purchase of energy can even be more profitable than direct production in the case of electrifications of considerable size which constitute a sufficiently constant load to serve as a base of the production of very powerful stations supplying a varied clientel at a cost price definitely less than that which the railway company could obtain. This

arrangement has the further advantage that it does not increase beyond measure the capital investments required by the electrification. These investments and the price of the power are both reduced if it is possible to take the supply at the substation instead of at the power station, by utilising the main feeder lines of a general distribution system which is easier to remunerate than special lines.

It would, therefore, appear that only in the case of electrifications of very great extent should a railway company produce power and operate a vast system of high tension lines. Even in this case it is advantageous to endeavour to obtain as far as possible the profit which the producers and distributors of electricity obtain by a general interconnection of their power stations and distribution systems ; it is only by this method that the railway company can lower its cost price thanks to the sale of the excess power and a better use of its high tension lines. The two solutions, moreover, may have to be combined by feeding at the same time electrified lines by railway-owned power stations and by current purchased from neighbouring supply companies.

In order to reduce the *power consumption* it is necessary to obtain as high an overall efficiency as possible from the whole of the transmission (conductibility of the high tension lines and especially of the contact lines), the transformation (substations), and the utilisation of the power (locomotives) : it is desirable, however, to follow up this objective without needlessly increasing the first costs (for the conductibility of the contact lines for example), as by increasing the capital charges the saving on the consumption of energy would be lost.

In the case of alternating current traction, the efficiency of transformation is very high when the primary current is of the same type as the traction current : if the supply is three-phase current at industrial frequency whereas the traction current is of a different type or frequency (single-phase or three-phase at low frequency) the efficiency is less and consequently the consumption higher, but the possibilities of interconnection on the primary system can nevertheless make this solution profitable thanks to the reduction of the cost price of the primary power.

In the case of direct current traction, the efficiency of the transformation is low with motor generator sets, but it becomes very satisfactory with rotary converters and quite remarkable in the case of mercury vapour rectifiers ; what matters is the *average efficiency* during the whole day, including generally quite long periods of working under low load, in which the differences of efficiency between these three classes of convertors are much more marked than at full load.

As concerns the use of the current on the locomotives, it is, for example, possible to reduce the consumption in certain cases by using *regeneration* on the down gradients ; it is, however, only in rather special circumstances that the saving of energy so realised is sufficient to justify the additional equipment required.

It should also be noted that the use of *rail motor trains*, the composition of which can easily be altered according to the varying requirements of each period of the day, makes it possible to reduce consumption of energy to the strictly necessary amount.

As regards the costs of *supervision and maintenance of the electrical installations*, they can only be reduced by additional capital expenditure to be considered relatively to the savings expected.

In certain cases the balance can be definitely favourable : such for example is the use of non-ferrous metals for the

contact lines exposed to corrosion by smoke, damp, fog, or sea mists on coastal lines, etc.

In the same order of ideas the use of automatic apparatus in the substations may be noted ; it is generally easy enough to see that the increased cost involved in the installation of automatic or semi-automatic substations is rapidly paid off by the savings on staff, to which savings can frequently be added a reduction in the energy consumed.

The comparison of the expenses under this section for electric traction and for steam traction leads to extremely varying results according to the cases.

Stress is sometimes laid on the saving of fuel which can be made in the case in which the electric energy is supplied by steam power stations thanks to their excellent efficiency as compared with the relatively smaller efficiency of the steam locomotive in spite of all the improvements made thereto during recent years; furthermore power stations are able to use fuel of indifferent quality, which would not be suitable for the locomotives.

But if we compare, as we have pointed out, the total expenditure necessary for fuelling the tenders and delivering current to the collectors on electric locomotives, the comparison is often unfavourable to electric traction. This is not, however, a reason for declaring electric traction uneconomical, because we are here dealing with only a single section of the balance sheet, the result of which can be counterbalanced by others.

2. — *Driving of locomotives and rail motor coaches.*

This section should include the total pay of the driving staff of the locomotives (wages, premiums, supplementary remuneration), with the corresponding general charges.

The comparison always shows an *important saving* in favour of electric traction, because the total staff required for carrying out the same service is definitely less for the various reasons we will analyse ; moreover, the driving of electric locomotives is much less trying than that of steam locomotives and only needs much simpler professional instruction ; the remuneration of this staff is often lower than that of the steam locomotive drivers and firemen.

The reduction of the staff is due in part to the fact that the work to be done *before the trains leave and after their arrival* is insignificant. Many administrations are taking steps, it is true, to simplify the duties of drivers and firemen of steam locomotives in this respect, by having this work carried out by the shed staff ; the increase in the cost of the shed staff is definitely less than the saving effected in the driving staff, but the saving so effected is relatively small compared with that resulting from electric traction where such operations whether carried out by the enginemen or the shedmen are almost entirely done away with.

The principal cause of the reduction in number of enginemen lies in the *greater power* of the electric locomotives whereby the same traffic can be worked with a smaller number of trains, the speed be accelerated, or certain assisting engines can be dispensed with.

In addition, when an assisting engine is necessary, it is still possible to save staff by fitting the electric locomotives with multiple-unit control, with which a single set of men can drive several locomotives coupled together ; it is however still necessary to use separate men for locomotives at different points in the train, either in front or at the back, or marshalled in the train according to the practice of certain administrations. So far the full benefit of multiple-control has only been obtained in the case of automotor trains consisting of special roll-

ing stock and on which all the vehicles, both trailer and motor, are fitted with through control gear throughout the train.

The same solution obviously cannot be applied to trains running long distances and even less to goods trains ; an attempt has however been made for the driver of the leading engine to drive electric locomotives marshalled in the body of the train or at the back of the train, without the vehicles having to be specially wired, but this again is only a question of experiments which up to the present have not given any practical results.

Finally, a further important source of saving is to be found in the use of a *single man* to drive electric motor vehicles : this method is the usual practice in the case of motor coaches, but it is interesting to note its recent extension to the locomotives themselves. Most of the administrations who use this method only authorise it however under certain restrictions relating to either the nature of the train or the presence of the continuous brake. Others require the head guard to travel with the driver : though there are then two men on the locomotive the full saving of staff is realised as the guard also continues to carry out his normal duties.

These various advantages taken together in the case of electric traction show considerable savings on the driving wages as compared with steam traction ; it is not unusual for the total economy under this heading to be about 50 %.

3. — *Maintenance and lubrication of locomotives and motor coaches.*

It is relatively easy to make a comparison as regards electric and steam locomotives, but the introduction of motor coaches complicates the problem ; from the cost of maintenance and of lubrication of the electric rolling stock those costs which would have been incurred for the ordinary coaches for which the rail motor coaches have been substituted must be deducted, otherwise the comparison would not be fair.

In the case of the locomotives, there is always *a notable saving* under this heading in favour of electric traction even when the electric locomotives are not appreciably more powerful than the steam locomotives with which they are compared ; the economy is much more marked when it is a question of very powerful electric locomotives, because the costs of repair and lubrication are far from increasing proportionally with the power.

The rate of saving varies considerably from one company to another, and the reporters have wisely avoided quoting any average ; it may, however, be said that in certain cases the saving on the costs of maintenance of the locomotives can reach or even exceed 40 % ; the saving on the cost of lubrication can be even greater, but this does not appreciably modify the result because the cost of lubrication is never more than a small percentage of the cost of maintenance.

4. *Heating of passenger trains in winter.*

The comparison of the expenditure to be brought to account under this heading varies according to the method of heating the electric trains.

For the motor coach trains the general rule is the exclusive use of electric radiators, and the same solution is frequently extended to local trains hauled by locomotives. But the question is more complex for rolling stock on trains running long distances : when the vehicles have to run over electrified lines for only a small fraction of the distance it is frequently advantageous to retain the steam heating, over the electrified section, either by installing a boiler on the electric locomotive, or by adding to the train a special wagon fitted with a heating boiler. If the distance to be run

over the electrified lines represents on the other hand a large fraction of the total distance, it is better to fit the rolling stock with electric radiators, at the same time retaining the steam heating equipment, so that it can be used over the other sections of the journey.

According to the case, therefore, the following expenditures should be compared : In the case of steam traction, the expenditure on fuel for heating is generally included in the locomotive fuel already accounted for ; as for the cost of maintenance of the heating fittings in carriages, it has only to be taken into account when it is a question of comparing rolling stock from which the fittings would have been removed and replaced by electric radiators, but they must be left out of account if the steam heating has to be kept in use on the electrified line, or even if the apparatus is simply retained for use on other sections.

In the case of electric traction it is desirable first of all to ascertain the consumption of energy for heating by electric radiators in the case in which it has not been done in the calculation of the traction energy. In addition the cost of maintenance of these electric radiators should also be taken into account, as also that of the fittings and wiring. If boilers carried on the electric locomotives or on special wagons are used, the cost of fuel used by these boilers ought to be ascertained, as well as the cost of other supplies, the cost of maintenance of the boilers or the special wagons, and if need be the cost of the staff working these wagons.

5. *Miscellaneous expenditure at the depots.*

Under this heading is included all expenditure at the depots not already included under the preceding sections, and in particular : cost of stabling engines, watching, cleaning of locomotives and motor coaches, removal of ashes, clinker, etc. On the other hand, it is not necessary to include in them the cost of handling fuel for example, if this has been already included under the first section as we have shown.

Although electric traction always makes it possible to effect substantial savings under this section, their value varies considerably according to the organisation of the service in the depots; it can, however, be noted that in certain cases this saving has been calculated at 40 % of the expenditure under steam traction.

6. *Maintenance of the permanent way.*

Under this heading only the expenditure which might be affected by substituting electric traction for steam traction has to be taken into account.

This is the case when as a result of doing away with the fumes it is possible to effect on certain electrified lines valuable savings on the maintenance of the track in tunnels, or on the maintenance of metal structures (over bridges, station buildings, signal gantries, etc.).

Inversely, the presence of the electric conductors near the track (3rd rail) or the structures (trolley wire) requires certain special precautions which may diminish the output of the staff and consequently increase the cost of maintenance.

7. *Train staff.*

Electrification generally leads to a speeding up of the trains and to an increase in their load and thereby makes it possible to reduce their number. In consequence a saving in the expenditure on train staff is frequently effected.

Such expenditure is frequently difficult to evaluate and, except in particular cases, it can only be mentioned as a reminder.

IV. — **Indirect advantages.**

We have already pointed out in this report certain indirect advantages of

electrification capable of being translated into figures representing invested capital, such as the possibility of avoiding the doubling of a line or the enlargement of a big station, the building of a new line with heavier gradients and consequently a cheaper lay-out, etc...

We cannot hope to enumerate all the advantages of this kind, naturally very variable, which electrification can produce in each special case. We will limit ourselves to mentioning as an example the increased value of land belonging to the railways inside the cities ; in this way the substitution of electric traction for steam traction has sometimes made it possible to build above the track important blocks of flats in the heart of a large city; when this operation has been carried out on a large scale a large part of the cost of the electrification has been paid thereby.

Other indirect advantages of electrification may *reduce somewhat the operating costs,* for example the reduction of the costs of maintenance and painting of metal structures, thanks to the suppression of smoke ; it has also been found for the same reason that there is a reduction in the cost of cleaning and maintaining the carriages, particularly those worked over lines having tunnels of considerable length. Owing to its greater regularity the electric working shows savings on the supplementary costs resulting from incidents and delays which are more frequent with steam traction. The increases of speed possible with electric traction improve the turn-round of the rolling stock, etc...

Finally electrification can be a source of *supplementary receipts.*

We have already shown the results obtained by selling the excess energy produced by the railway power stations, or sums received in payment of the transmission of other firms' power over its own high tension systems.

The development of the passenger traffic on electrified suburban lines must also be pointed out. It has also been found that on certain lines over which the service was none too good both as regards speed and density, thanks to electric traction the competition of road vehicles fell off considerably or even disappeared : electrification has therefore made it possible for the railway to recover the traffic which has been taken from it.

The increase in receipts can also be obtained from the industrial development of a region so far not provided with any supply of electric energy, and in which the construction of the necessary feeders required for the electrification of the railway involves the setting up of a vast distribution system : this advantage, naturally more marked in new countries, has however been observed in many areas already served for a long time by the steam railways.

There are still other advantages which while being of an *economic order* in the strictest sense, cannot however be shown on the balance sheet of the electrification considered solely from the railway point of view ; these are the advantages which benefit the financial position of the country.

The railway profits indirectly, it is true, but it is impossible for it to take such advantages into consideration in its own balance sheet.

In particular such are the results which the electrification of the railways may have on the reduction of the importation of foreign coal, through the use of domestic resources whether by harnessing water falls or by utilising in large steam power stations domestic fuel of too poor quality for use on steam locomotives. When considering the influence of such an operation on the financial position of a country the counterpart (moreover small as a rule) must not be lost sight of, namely the import-

ation of copper or even of electrical equipment when they cannot be provided in the country itself.

V. — Summary.

1. Electrification is in general characterised from the economic point of view by a heavy increase of the capital charges, by savings, frequently considerable, on the operating costs, and finally by indirect advantages which in certain cases may play the predominant part; the balance sheet of the electrification should therefore include all these elements.

2. It is always difficult to draw up this balance sheet accurately owing to the uncertitude which exists as to the evaluation of certain factors, sometimes of considerable importance.

3. The diversity of the accountancy methods makes it difficult to compare the balance sheets drawn up by the different administrations, especially as regards the industrial amortisation of the fixed plant and the rolling stock.

4. As the total capital charges may exceed the operating costs in the case of electric traction, whereas they only represent a small fraction in the case of steam traction, fluctuations in traffic are capable of modifying radically the aspect of the balance sheet of electrification.

5. Apart from special cases (suburbs of large cities, mountain lines, lines on which the limit of capacity has been reached, abnormally high fuel costs, etc.), electrification is usually only economical if money can be obtained at a low rate, if electric power can be obtained at a favourable price, and if the traffic is proportionally heavier as the gradients of the line are easier.

6. The economic considerations proper to the railway itself are not the only ones which may decide the electrification of a line : the decision may be the result of considerations relating to the general economics of the country, or of requirements of a technical nature quite apart from any question of finance.

PART II.

Selection of sites for generating stations.

Report No. 1 is the only one dealing in any fullness with the selection of sites for generating stations ; it develops on the one hand the general considerations involved and on the other the considerations special to steam power stations, hydro-electrical stations, and stations using internal combustion motors.

In the other reports this question has been joined up with that of the methods of supplying power for electric traction, either by special generating stations belonging to the railway, or by the purchase of power from private generating stations, or by a combination of the two methods. But this last question is closely linked up with that of obtaining energy at the most favourable price, and this is the reason why we have preferred to speak of it in the part of the report dealing with the study of electrification from the economic point of view, as the writer of Report No. 1 has also done.

The supply of power for an electric traction system does not differ from the supply to an ordinary distribution system for general purposes, except by the importance of the momentary peak loads, — by much more severe requirements from the point of view of security and continuity of supply, — and in certain cases by the use of alternating current at frequencies definitely lower than the industrial frequency.

It must be noted however that the relative importance of the momentary peak loads falls off considerably as soon as the electrification covers a group of railway lines with sufficiently dense and varied traffic. In the same way, the

extension of the electrified system by necessitating several distinct supplies results *ipso facto* in the realisation of the necessary guarantees of security of supply of the power. Finally the use of low frequency alternating currents can be conciliated in many ways with the production of current at industrial frequency — either by the use of separate groups in a station, — or by using alternators with different frequencies on the shaft of a single motor, — or by the conversion of the primary current at industrial frequency on the outgoing side of the generating station, or in special transformer stations, — or even in the traction substations.

In any case, if these particular features influence the choice of the method of supplying power (special generating stations or the purchase of energy), they do not appear to have, according to the three reports, any effect on the *site of the generating stations.*

Once the programme of supplying energy to the electrified lines has been decided, the selection of the sites of the generating stations ceases to be a railway problem, and in no way differs from a similar investigation concerning the production of the power required to feed any distribution system or any large centre of consumption.

It does not, therefore, appear that this part of Question V can be usefully discussed in detail by the Congress, as it is rather a matter for the producers and distributors of electricity.

Summary.

Under reserve of the special requirements of electric traction, the selection of the sites for the generating stations supplying power to electrified railway lines is governed by the same considerations as in the case of generating stations feeding ordinary distribution systems or large centres of consumption.

PART III.

Choice of the kind of current.

I. — General remarks.

The various systems of electric traction are commonly designated according to the kind of current used *on the contact line* (trolley wire or conductor rail) and picked up by collectors on the locomotives and motor coaches (pantographs or shoes); the reporters have considered that the question of the kind of current, laid before the Congress, should be dealt with in this sense.

It frequently happens, however, that an electrified system employs different types of current from that adopted in certain parts of the installation on the contact line. This is often the case as regards the production of energy in the generating stations and its transmission to the substations. In addition, the trolley wire current is sometimes transformed on the locomotives themselves into current of a different kind for the traction motors.

These features can appreciably affect the choice of the kind of current to be used on the contact line; though the question only relates to this latter current it is not possible to deal with it without taking into account the kinds of current used in the other parts of the installation.

II. — Electric traction system.

In the chronological order of their application on a large scale, the different systems of electric traction in use at the present time can be classified into three groups, according to the kind of current used on the trolley wire, namely: *direct current* systems, *threephase current* systems, and *single-phase current* systems.

a) *Direct current systems.*

The first electrifications were carried out with *direct current at tensions of*

about 600 volts, the current being picked up from an insulated rail known as the « third rail ».

Apart from the metropolitan railways on which this method of supplying current to the motor coaches is still almost general, this system has undergone a vast extension on many railways having particularly developed suburban services. In this case, in fact the cost of the motor coach stock plays a predominant part in the total cost of electrification, which justifies the adoption of relatively low voltages, in spite of the consequences resulting from a greater number of substations. These considerations explain why this system has also been used for some electrifications with, in addition to the suburban service, long-distance trains hauled by powerful locomotives.

Nonetheless, the use of such low tensions does not appear to be reconcilable economically with the extension of electrification to lines of great length run over by heavy trains, and much less frequent than suburban trains : this is why the application of direct current to electrifications of this kind could not be considered so long as the builders were not able to build readily direct current machines for considerably higher voltages, whence the necessity for resorting in such cases to alternating current.

It is only during the last twenty years that direct current traction has undergone a new development thanks to the progress which has made it possible to use this type of current at *voltages of from 1 500 to 3 000*, according to the particular conditions under which the problem of the electrification presents itself ; when the traffic is sufficiently dense and especially if the suburban services form an appreciable portion thereof, it can be advantageous to be satisfied with a tension of 1 500 volts, whereas that of 3 000 volts is more economical in the contrary case.

Overhead trolley wires are always used in the case of electrifications with direct current at tensions of about 3 000 volts. The same is generally the case with 1 500 volts ; the example of the electrified Modane line on the Paris Lyons and Mediterranean Railway [100 km. (62 miles)] of double track shows that the third rail can be used with success at a voltage of 1 500, even with very powerful locomotives hauling heavy express trains at very high speeds.

All direct current locomotives and motor coaches are arranged so that the traction motors use the current as picked up on the contact line. The direct current series motor moreover has good characteristics, and is very robust. By using series parallel coupling and shunting the field magnets, a sufficient number of speeds is available to meet the very varied traffic conditions with sufficient elasticity.

With very few exceptions, applying to old and limited installations, direct current is not produced directly in the generating stations; electrifications using continuous current are generally characterised by the use of *three-phase current at industrial frequency* for the production of the energy and its transmission to the substations. These latter can therefore be connected with a general distribution system which makes it unnecessary to build special generating stations or even separate transmission lines.

Until recent years the three-phase current was transformed into direct current in the substations by means of rotary convertors so long as the current did not exceed 1 500 volts ; beyond this it was necessary to use motor generator sets, which cost considerably more and are less efficient. However, since the manufacture of mercury rectifiers has been perfected, the tendency is to equip the substations with this latter type of apparatus, the particularly high effi-

ciency of which only falls off moderately with the load; this characteristic is very valuable for traction substations which have frequently to work under small load during long periods. However, the rectifiers have not yet supplanted the convertors or the motor generator sets when it has been found profitable to regenerate when running down gradients; recent improvements, however, make it possible to think that this last reserve may soon be removed.

b) *Three-phase current systems.*

The three-phase current system has only been used on a large scale by the Italian Railways where its adoption was due to considerations which can today be considered as *historical :* on the one hand the necessity for considering an electrification on a vast scale using a line voltage much higher than those then reached with continuous current (600 to 800 volts), — and on the other hand the desire to use very robust traction motors at a period when the single-phase motor had not yet been proved out.

The voltage on the contact line was, however, limited to 3 700 volts, both to facilitate erecting the double overhead line and to make it possible to use directly the current in the traction motors without having to fit transformers on the locomotives. As regards the frequency it was fixed at a sufficiently low value (first 15, then 16 2/3 cycles) so that motors driving direct or through rods could be built without gears, the manufacture of which could not be guaranteed at that time.

Besides its great robustness, the three-phase motor has the advantage of lending itself automatically to electric braking by regeneration when running down gradients. Against this, it is only possible to have several working speeds on the condition of coupling the motors in cascade, or by changing the number of their poles; nonetheless by combining these two methods the Italian engineers have succeeded in building very remarkable locomotives, perfectly suited to varied service, and of very light weight relatively to their power.

In order to make the whole installation *as simple as possible,* three-phase current was produced at low frequency directly, which required the construction of special generating stations and separate feeder lines. It was subsequently found possible to improve the use of the generating stations by fitting them with generating sets at industrial frequency and with low frequency groups, or even by fitting on the same shaft two alternators at different frequencies. A further step has recently been made towards the *standardisation of frequencies* at the generating stations and on the primary distribution systems : the power is produced as three-phase current at industrial frequency and transmitted by the general distribution system to large transformer substations which supply low frequency current for feeding a group of traction substations. The system loses in this way part of its original simplicity, but against this profits from the financial advantages resulting from concentrating the production of energy in large central generating stations interconnected by a high tension grid transmitting power for all purposes : lighting, power and traction.

A recent trial carried out successfully by the Italian State Railways on the Rome to Avezzano line has shown that the limitations imposed by the knowledge available when three-phase traction was introduced, both as regards the voltage and the frequency, can today be ignored. On the one hand, the example of the single-phase locomotives has shown that the installation of transformers on the locomotives has no disad-

vantage, whence the possibility of considering the use on the contact line of much higher voltages, limited only by the conditions of insulation of the double trolley line on the three-phase system. On the other hand, thanks to the geared drive today in general use, it becomes possible to build the locomotives with three-phase industrial frequency motors. In this way the Italian engineers have succeeded in perfecting a three-phase installation at 10 000 volts and 45 cycles, the working of which has given them full satisfaction ; they have thus solved at the same time the problem of feeding *industrial frequency three-phase current* and that of using it on the contact line at a tension approaching that in use on simple-phase lines.

In spite of these successful results, however, they have nonetheless decided to adopt direct current at 3 000 volts for any electrifications undertaken outside the zone in which the three-phase low frequency system has already been employed on a large scale. This decision was first of all due to a desire to *avoid the double overhead trolley line* of the three-phase system, the installation and maintenance of which, especially in the case of lines over which expresses work are more delicate and more expensive than in the case of the single line used with the direct-current or single-phase systems. In addition, no matter how perfected the three-phase locomotives may have been made by the Italian engineers, the *speed regulation* is still less flexible than with the other systems.

It appears therefore that the three-phase industrial frequency system is hardly likely to be used for new applications. As regards the three-phase low frequency system, its use would appear to be limited to the regions in which it is used at the present time ; apart from its extension to new lines in this zone it is probable that it will not be used in the future in other countries.

c) *Single-phase systems.*

The single-phase system is used on a large scale in Europe, at 15 000 volts, 16 2/3 cycles and in the United States of America at 11 000 volts, 25 cycles.

These frequencies lend themselves to the direct use of the current in the traction motors of the series single-phase type, after simply reducing the voltage in a multiple step transformer; the variations of speed being obtained by passing from one step to another on the transformer, this system gives great facility as regards the *flexible and exact regulation of the speed of the locomotives* within wide limits.

In special cases where it was desired to obtain different characteristics instead of single-phase motors, either three-phase motors or direct current motors have also been used by converting the current on the locomotives themselves by means of phase convertors in the first case and by motor generator sets in the second. Thanks to these arrangements, the use of single-phase current on the contact line therefore lends itself to the construction of locomotives meeting very varied needs.

Owing to the *very high voltage* on the contact line, the single-phase system makes it possible to transmit very great power over lines of remarkable lightness. In addition, the substations can be spaced wider apart under the reserve, however, of the limitations imposed in certain cases by the need for preventing inductive disturbances in telegraph and telephone lines. These substations are moreover very simple as they only include static transformers.

Most frequently the desire to *simplify* the installations has resulted in the power stations producing directly single-phase current, especially when it is a question of 25-cycle current, unsuitable for any purpose other than traction.

When three-phase, 25-cycle current

was available, the production of single-phase current has been rendered unnecessary thanks to the use of special transformers combined with the installation of rotary machines to balance the load on the three phases of the primary circuit.

But outside zones where the high-tension single-phase mains specially set aside for traction purposes are already widely extended, it has been noticed in recent years that there is a very clear tendency to produce the single-phase current by means of convertor groups *branched on the industrial frequency three-phase system*, and this for the reasons given above. The same problem will probably be solved shortly and practically without the use of revolving machinery thanks to the mercury vapour valve with polarised grids.

It is interesting to note, in the same order of ideas, the tests carried out by Hungarian Railways on the direct use of industrial frequency alternating current on the contact line, by installing convertors not in the substations but on the locomotives ; by feeding the successive sections of the single-phase trolley wire with the different phases from a primary three-phase system, the problem of balancing the loads on the phases of this system appears to have been solved in an acceptable way. These tests appear likely, therefore, to lead to a new solution of the problem of feeding a single-phase traction system by means of industrial three-phase current, and the more so as it will be possible to convert the current on the locomotives by several methods ; in addition to the rotary convertor tested by the Hungarian Railways, the use of mercury vapour valves for the same purpose could be considered.

III. — Choice of the system of traction.

To select the system of traction to be used for a given electrification is evidently to look for the one which is capable of giving the service in the most satisfactory way at the lowest price, it being understood by this that the total price, including capital charges and operating costs, is meant.

Consequently therefore this choice depends to a certain extent on the *technical progress* made, owing to the subsequent effect this can have on the working of the service and on its cost price.

In the past, the development of technical knowledge played the main part and caused hot arguments between the partisans of the different systems as each was perfected in turn.

But as ideas have developed and improvements been made in each system, this aspect of the problem now appears to be of secondary importance.

The best proof is that, except in certain exceptional cases when the single-phase current originally adopted has been abandoned for direct current, each administration has retained, when extending its original electrifications, the system it first selected.

We have pointed out, however, that in spite of the brilliant results obtained in Italy with the three-phase system, it seemed correct to think that it will not be used in future outside the zone where it was developed. In the case of new electrifications, the choice will in future be between *direct current* and *single-phase current*.

The advantages of a technical nature that can be brought forward in favour of one or the other of these systems ought not, in future, to exercise a decisive influence on this selection, except perhaps in quite particular cases.

Thus for example the necessity to be satisfied with direct current with appreciably lower voltages than with the single-phase current does not appear to constitute a technical objection to the extension of the first system. Though the most powerful locomotives in use at the present time are single-phase locomotives, against this several railways

are using direct-current locomotives, the power of which exceeds 3 000 H.P. and sometimes even 5 000 H.P. As these last engines only work at 1 500 volts, we may conclude that there would be no difficulty in building more powerful machines still, if necessary by resorting to 3 000-volt current The present possibilities of direct current are thus able to meet the most difficult demands that may occur in practice ; consequently it would only be in quite exceptional cases that the necessity for a particularly high voltage would result in this system being set aside.

In the same way, if it is true that the speed can be more easily and more accurately adjusted with the single phase system, it must be admitted that the direct-current locomotives can be given such speed ranges as practically meet the most varying demands.

The direct-current substations — more complicated, it is true, than those for single-phase current — can be operated economically thanks to the use of mercury vapour rectifiers and automatic or distance-controlled apparatus.

Against this, with the present tendencies, the advantages of supplying three-phase industrial frequency current are no longer the privilege of the sole direct-current substations, and the perfecting of new methods (mercury vapour and polarised-grid valves, or industrial frequency singe-phase current) can only reduce in the future the difference which exists from this point of view between the two systems.

The result of the above is that the choice of the kind of current is scarcely a matter of pure economics at the present time, i.e. the technicalities proper to each system no longer affect the comparison except as regards their repercussion on the capital charges and operating costs.

The balance is, therefore, the more difficult to establish as these repercussions can inversely affect both these two headings of expenditure, the total amount of which alone matters.

In fact, the reporters agreed to conclude that no theoretical comparison appeared to be possible, and that the question would only be treated by *actual cases* under the condition, moreover, of including, in the problem, the operating costs and capital charges corresponding to all parts of the installation, from *the supply of energy to* its use, including the expenditures sometimes incorrectly qualified as accessory.

In view of the impossibility of formulating a conclusion of general application, it becomes necessary to limit ourselves to *stating the fact* that in recent years single-phase current has only been applied for extending previous electrications, or for new electrifications on lines closely connected with those already electrified on this system : everywhere else, when the question of the current has been an open one, direct current has been adopted.

It would certainly be an error to give this simple statement of fact a special meaning which it does not possess. If in the great majority of proposed electrifications which have been actually considered in recent times, the direct-current solution has been considered as the most suitable, this in no way signifies that other problems may not arise in sufficiently different conditions for the solution to be also quite different ; this observation was as applicable to the past as it is to the future. It is reasonable to think that outside electrifications already earmarked for each system, direct current and single-phase current are both capable of meeting future new requirements.

IV. — Summary.

1. The choice of the kind of current for electric traction formerly influenced

by technical considerations, is today a problem of a purely economic nature.

2. This choice can only be determined in each case by taking into account the whole of the conditions of the problem put forward, and by comparing the whole of the expenditure (operating costs and capital charges).

3. The three-phase system appears unlikely to be used for new applications outside the zone in which it is used at present, so that in the case of new electrifications the choice would appear to lie between direct current and single phase current only.

4. Although continuous current has been adopted in recent years whenever it was not a question of extending an electrification already undertaken on another system, or of electrifying lines closely connected with others already electrified on a different system, the two systems, direct current and single-phase current appear to be suitable for future use in new electrifications outside their present fields of application.

PART IV.

Safety measures.

I. — Generalities.

The reporters agreed that the question considered especially the *safety of persons* (railway staff and persons not employed by the railway) rather than that of the equipment itself.

They also considered that only safety measures *specially related to electric traction* were in mind, to the exclusion of those common to other methods of traction or to other means of using electric energy ; they have, therefore, in particular not called attention to practices already followed up in all the installations for producing and distributing electric energy for various purposes.

II. — Generating stations.

The safety measures adopted in the stations producing electric energy for traction purposes do not differ from those observed in generating stations feeding distribution systems for general purposes.

At the most we can point out with one of of the reporters the necessity for using switches of ample capacity, and of organising with care their supervision and maintenance, in view of the frequency and violence of short circuits on the electric traction lines.

III. — High-tension lines.

The maintenance of the high-tension lines feeding traction substations requires the same safety measures as in the case of general distribution lines, and especially the cutting off of the current and earthing of the lines before starting repairs.

This obligation frequently leads to the necessity for duplicating the lines to maintain the supply to the substations by one of them when the other must be made dead and be earthed for repairs. In such cases the safety of the staff is completely assured when the two lines are carried on separate pylons. Sufficiently satisfactory safety conditions may, however, be obtained by carrying the two lines on the same pylon, provided the distance between them is sufficient to enable the men to work without danger while the other line is alive. This distance can be reduced by providing at the top of the pylons fixed or movable protection frames separating the two lines.

In America, certain repair work is allowed on lines under voltage, by using certain selected staff, employing impregnated wood platforms and tools with insulated handles.

IV. — Substations.

The protection of the staff operating and maintaining the substations includes the same measures as in all other installations of the same kind ; they ought, however, to be the more carefully looked after as the staff is smaller (sometimes only one man) and less well instructed than that at the generating stations.

V. — Trolley wires.

At all points where the public have access to the neighbourhood of trolley wires, notices are put up to call attention to the danger ; in addition bridges or footbridges over trolley wires are fitted with protecting screens.

As regards the railway staff, they must be made to understand that the trolley wires are always under tension, so long as the steps needed to cut off the current and earth them have not been taken. Even on systems where the presence of current on the line is confirmed by light signals, the extinction of the signal should not be considered as indicating that the lines are no longer under voltage.

The loading and unloading of vehicles should not be carried out on a line fitted with a trolley wire unless this latter has previously had its current cut off and been earthed.

The same rules generally apply to operations requiring a man to be on the roof of a vehicle. On certain railways, however, it is not necessary in this case to cut off the current from a trolley wire or to earth it if the wire is installed sufficiently high for the danger to be avoided ; in such cases notices are put up at places where the lines lower to a dangerous extent. On the American Railways where the men have sometimes to walk over the roofs of vehicle when running, they are usually forbidden to do this on the electrified lines; if this instruction cannot be laid down in an absolute fashion, fixed lights show the points where the line descends below the normal height.

Certain railway companies do not allow the staff of trains running over electrified lines to occupy elevated brakeman's cabins unless they are entirely closed in ; others only allow the elevated cabins to be used in the absence of wagons with low cabins and on keeping in view the danger due to the trolley wire.

Protective measures also are taken when steam locomotives run under trolley wires : apart from the requirements relating to the precautions to be observed either in using long fire irons or to prevent water being squirted on the trolley wire, the danger is called to notice by plates put up in the locomotive cab ; in addition certain administrations fit their tenders with hoops limiting the movement of the fire irons, or with large tubes in which these tools can be placed directly they are taken out of the fire box.

The road traffic is occasionally protected at level crossings by light load gauges, installed at right angles to the road, at a lower height than the trolley wire.

To prevent the voltage being unexpectedly put on the pylons or gantries carrying the contact lines, or other metal buildings close to these lines, the pylons and structures are connected directly to the rails forming the return circuit; a more economical but less effective arrangement consists in fitting the pylons with earthing plates ; the two arrangements are sometimes combined. One of the reporters points out that when the pylons are directly connected to the rails there are certain drawbacks; the difficulty may be overcome by inserting in the earth lead an arrangement including a very small air gap.

When carrying out repairs, it is usually laid down that the trolley wires shall first of all have the current cut off and be earthed ; this last precaution is quite

easily taken by connecting the contact line to the rails by means of portable devices. Some administrations, however, allow certain repair works of small importance to be carried out on the trolley wire while it is under voltage : these exceptions generally apply to direct current at 1 500 volts, but the case also arises in America for single-phase lines with 11 000 volts ; naturally such works are only carried out by exceptionally well-trained staff who must observe certain special precautions (use of impregnated wood ladders, only one man to be allowed on the ladder at the same time, etc.). In any case, the steps taken for the maintenance of the contact line also apply to work being carried out on metal parts near it.

VI. — Conductor rails.

While the attention of the public is called by means of posters or notices to the danger of the conductor rail, this rail is fitted with a guard, generally in wood, to lessen the risk of accidental contact with it. When the rail is under a tension of about 600 volts, this protection is usually only fitted in stations and on certain lines which are accessible to the public even on the open road. On the Modane line of the Paris Lyons and Mediterranean Railway the conductor rail under 1 500 volts is protected throughout its length, even on the open road, although this is only accessible to the railway staff.

The operations of loading and unloading vehicles standing on a line fitted with a conductor rail are as a rule only carried out after the current has been cut off and the line earthed. Special precautions are laid down in the case of the men responsible for examining the stock on lines on which the conductor rail is kept under voltage.

Certain railways allow slight repairs to be carried out on the 600-volt conductor rail, if special precautions are taken (rubber gloves, insulated boards, etc.) ; in the case of other work the conductor rail must have its current cut off, but it need not be earthed on every railway. For 1 500-volt rails, the Paris Lyons & Mediterranean Railway requires the current to be cut off and the rail earthed before every repair operation, even of the least importance.

When it is a question of work carried out not on the conductor rail itself but near it, to maintain the track for example, it is generally not thought necessary to cut off the current or earth the line (even if it a question of a rail under 1 500 volts) but wood shields are then placed over conductor rails or tools with insulated handles are used.

VII. — Electric locomotives and motor coaches.

The task of the driver of an electric locomotive or motor coach is much simpler than that of the driver of a steam locomotive ; in addition, the position he occupies, as well as the freedom from smoke and steam make it much easier to see the signals ; finally the work of his assistant cannot be compared with that of a fireman on a steam locomotive. This is the reason why in certain cases the electric rolling stock is driven by one man. As a safety measure the locomotives or rail motor coaches driven by one man are generally fitted with the arrangement known as the « dead man's handle » which automatically causes the current to be cut off and the brake applied in the event of any failure on the part of the man. This practice, of normal use on rail motor coaches, has been extended to the electric locomotives on many railway systems without any drawback having resulted. The application has, however, been limited to trains fitted with continuous brakes and not exceeding certain speeds, such as 75 km. (46.6 miles) an hour. Furthermore on certain railways the head guard is obli-

ged to travel in the driver's compartment, or to be near it so that he can intervene at once.

Most electric locomotives are fitted with arrangements preventing the men from getting onto the roof until the pantographs have been lowered and locked in this position; most frequently the ladder for getting up to the roof is kept in its folded position by a lock the key of which is interlocked with the control of the pantographs. The same arrangement is frequently adopted to prevent the opening of the panels or lattice works closing in certain parts of the interior apparatus, while they may be put under voltage.

Special precautions have been taken to avoid accidents which could result from handling the connections between the locomotives, rail motor coaches, or coaches, when these connections are under tension ; in certain cases they are locked in their sockets so long as the current has not been cut off ; in other cases the connection boxes are interlocked by reciprocal locks with the switch of the feeder circuit in question on the locomotive.

In the case of anything occurring on the open road the staff are required to lower the pantograph before undertaking even the smallest repair ; if it is necessary to get onto the roof, certain administrations lay down, in addition, that first of all the current has to be cut off the trolley wire, and the driver is then required to protect himself against the line being accidentally put under voltage by a portable arrangement for earthing it. Similar precautions are laid down in the case of lines using a third rail : in certain cases the locomotives are in addition fitted with a special arrangement whereby it is possible to make a full short-circuit between the rails of the track and the conductor rail to suppress the tension on the latter without having to apply to the substations.

In the case of repairs on the electric locomotives and motor coaches in the depots, steps are taken to prevent the apparatus being put under tension while repair operations are being carried out on track fitted with contact lines. As regards important repairs, they are generally carried out on track not fitted with contact lines, so that all danger is avoided.

VIII. — **Miscellaneous.**

Electrified lines should be fitted with more highly developed telephone systems than in the case of steam traction lines, in order to carry out the necessary communications between the power stations, substations, railway stations and depots, and even signal boxes on the open road ; on certain lines telephone connections are provided the whole length of the line at close intervals, and portable telephones are distributed to the maintenance gangs and to the driving staff of the locomotives. Such means of communication not only serve to reduce the period the current is interrupted required for repair work or through something going wrong, but they also contribute largely to the safety of the staff.

One of the possible dangers of using high voltage current is the risk of fire ; consequently fire extinguishers are fitted not only in the generating stations and substations, but also on the locomotives and rail motor coaches. The most widely used type is the extinguisher using carbon tetrachloride, giving a non-conducting jet, which can be used even when it is not possible to cut off the current beforehand on the part of the system where the fire has occurred ; these extinguishers, however, give off deleterious gases and therefore require certain precautions (use of masks for example) when used in confined places. One of the reporters calls particular attention to the need for providing against the danger of fire when loading

or unloading inflammable liquids in the case of tank wagons standing on lines through which stray currents from the return circuit of an electrified line might flow.

In spite of the precautions taken is it inevitable that from time to time accidents through electric shock should occur ; consequently great care is taken to instruct the staff in the steps to be taken in such a case, especially as regards giving artificial respiration ; in order to facilitate the application of artificial respiration certain railway systems provide in the substations, depots, stations, and even in the signal boxes on the open road, apparatus by which artificial respiration can be given mechanically during a prolonged period without fatiguing the operator. Some administrations also put at the disposal of the staff oxygen equipment, sets for giving ether injections, etc...

IX. — **Results obtained.**

The statistical information supplied by the administrations operating electrified lines show clearly that the accidents imputable to the use of electricity for traction purposes are fortunately rare, which proves the efficacy of the steps taken to assure the safety of persons.

Most of the accidents are moreover the consequence of mistakes by the victim, or of manifest imprudence or serious negligence.

Accidents affecting the public are quite exceptional ; some are mentioned which occurred for example when loading or unloading vehicles, but no administration reports accidents to passengers themselves (it being understood that we are only dealing here with accidents due to electricity, and not to other causes such as collision, derailment, etc.).

As regards the staff, accidents are particularly rare among the men of the permanent staff of the railway, but more frequent among temporarily employed staff, or among contractors' men working for the railway. Certain statistics bring out in addition the fact that accidents occur more frequently when the electrification is new than subsequently.

We can therefore deduce on the one hand that the risk becomes very much less as the staff becomes familiar with the precautions to be taken as these by habit tend to become instinctive. It also shows that newly recruited or temporarily employed staff on an electrified line must be given accurate and frequently repeated instruction, and that close supervision must be exercised over them till they have acquired this rather special professional education.

X. — **Summary.**

1. Apart from safety measures in general use in all plants using electric energy, suplementary measures are taken on electrified lines to protect the public and the staff against the particular dangers which the contact lines (trolley wire or conductor rail) and the electrical equipment of the locomotives and rail motor coaches may present.

2. The efficacy of these measures is proved by the few accidents which can be ascribed to the use of electrical energy for traction purposes.

3. Most of these accidents are the result of a mistake committed by the victim, his imprudence or his negligence.

4. These accidents occur especially when the electrification is new, and principally affect staff still insufficiently familiar with the steps to protect themselves, whence the necessity for specially looking after this part of the professional instruction of newly recruited staff, or staff employed temporarily, as well as of staff employed by contractors.

Proposed summaries for question V.

I.-1. — Electrification is in general characterised from the economic point

of view by a heavy increase of the capital charges, by savings, frequently considerable, on the operating costs, and finally by indirect avantages which may in certain cases play the predominant part ; the balance sheet of the electrification should therefore include all these elements.

I-2. — It is always difficult to draw up this balance sheet accurately owing to the incertitude that exists as to the evaluation of certain factors, sometimes of considerable importance.

I-3. — The diversity of the accountancy methods make it difficult to compare the balance sheets prepared by the different administrations, especially as regards the industrial amortisation of the fixed plant and rolling stock.

I.-4. — As the total capital charges may exceed the operating costs in the case of electric traction, whereas they only represent a small fraction in the case of steam traction, fluctuations in traffic are capable of modifying radically the aspect of the balance sheet of electrification.

I-5. — Apart from special cases (suburbs of large cities, mountain lines, lines on which the limit of capacity has been reached, abnormally high fuel costs, etc.), electrification is generally economical only if money can be obtained at a low rate, if the electric power can be obtained at a favourable price, and if the traffic is proportionately heavier as the gradients of the line are easier.

I-6. — The economic considerations proper to the railway are not the only ones which may decide the electrification of a line : the decision may be the result of either considerations relating to the general economics of the country, or by necessities of a technical nature quite apart from any question of finance.

II. — Under reserve of the special requirements of electric traction, the selection of the sites for the generating stations supplying power to electrified railway lines is governed by the same considerations as in the case of generating stations feeding ordinary distribution systems or large centres of consumption.

III-1. — The choice of the kind of current for electric traction formerly influenced by technical considerations is today a problem of a purely economic nature.

III-2. — This choice can only be determined in each case by taking into account the whole of the conditions of the problem put forward, and by comparing the whole of the expenditure (operating costs and capital charges).

III-3. — The three-phase system appears unlikely to be used for new applications outside the zone where it is used at present, so that in the case of new electrifications the choice would appear to lie between direct current and single-phase current only.

III-4. — Although direct current has been adopted in recent years whenever it was not a question of extending an electrification already undertaken on a different system, or of electrifying lines closely connected with those already electrified on a different system, the two systems, direct current and single-phase current, appear to be suitable for future use in new electrifications outside their present fields of application.

IV-1. — Apart from the safety measures in general use in all plants using electric energy, supplementary measures have been taken on electrified lines to protect the public and the staff against the particular dangers which the contact lines (trolley wire or conductor rail) and the electrical equipment of the

locomotives and rail motor coaches may present.

IV-2. — The efficacy of these measures is proved by the few accidents which can be ascribed to the use of electrical energy for traction purposes.

IV-3. — Most of these accidents are the result of a mistake committed by the victim, his imprudence or his negligence.

IV-4. — These accidents occur especially when the electrification is new, and principally affect the staff still insufficiently familiar with the steps to be taken to protect themselves, whence the necessity for specially looking after this part of the professional instruction of newly recruited staff, or staff temporarily employed, as well as of staff employed by contractors.

[625 .2 (0]

QUESTION VI :

All-metall rolling stock : carriages and wagons. Use of light metals and alloys. Use of autogenous welding,

by E. DÄHNICK,

Special Reporter.

The question of all-metal construction of carriages and wagons has been dealt with in the following reports:

Report No. 1 (America, Great Britain, Dominions and Colonies, China and Japan), by Mr. H. N. GRESLEY (1).

Report No. 2 (all countries except America, Great Britain, Dominions and Colonies, China, Japan, Germany, Bulgaria, Denmark, Finland, Norway, Netherlands and Colonies, Rumania, Sweden, Czechoslovakia and Turkey), by Mr. R. MARIANI (2).

Report No. 3 (Germany, Bulgaria, Denmark, Finland, Norway, Netherlands and Colonies, Rumania, Sweden, Czechoslovakia and Turkey), by Mr. E. DÄHNICK (3).

The compilation of this special report was particularly facilitated in that the reports of Messrs. Gresley and Mariani were both based on the same questionnaire, and that there was no difference in the conclusions drawn by these two gentlemen.

The questionnaire was sent to 221 railway administrations in all; out of the 120 who replied, only 59 dealt with the subject in any detail.

A. — Passenger coaches.

I. — Advantages of all-metal carriages.

Of the 59 railway administrations who have sent comprehensive replies, 35 have already decided upon the eventual use of all-metal construction for all carriages; with 14 administrations the question of the general introduction of steel stock is still under consideration; 2 railways wish to adopt all-metal consruction for particular kinds of carriages only, while 8 have declared themselves opposed to the introduction of all-metal stock.

The following reasons are given by the railway companies who have adopted steel construction, for their preference as against wooden construction :

Greater safety in case of accident;

Greater strength, and therefore the possibility of building larger and more comfortable carriages; Elimination of body noises;

The advantage of being able to secure all outside plates and interior fittings more rigidly to the body framing;

Reduced repairs;

Cheaper maintenance;

Longer life and consequently the possibility of spreading the original cost over a longer period;

Decrease in danger from fire.

The managements who have not yet decided conclusively in favour of all-metal construction, or who favour the retention of wooden construction, are, on the other hand, afraid that building all-metal stock will have the following disadvantages :

Higher manufacturing costs;

Increased maintenance costs on account of the corrosion of the outer metal sheets;

(1) *Bulletin of the Railway Congress*, August 1932, p. 1467.

(2) *Bulletin of the Railway Congress*, October 1932, p. 1839.

(3) *Bulletin of the Railway Congress*, November 1932, p. 2059.

Heavier weight of the metal vehicles;

Greater liability of the walls to drumming noises and greater susceptibility to temperature fluctuations;

Larger steam consumption for heating purposes.

It is pointed out that wooden vehicles simply covered with metal sheets give sufficient safety against fire from outside sources (sparks).

In addition, the workshops are fully equipped for the building and maintenance of wooden vehicles and, in consequence, certain railway companies consider it desirable to proceed very cautiously as regards the introduction of all-metal construction.

The railways who are not in favour of the introduction of all-metal carriages are situated, in some instances, in countries with great timber resources, and would have to import metal constructional material. Other administrations justify their opinion by stating that in their countries the vehicles would be subjected daily to considerable temperature variations (Africa), or as in India, to an extremely damp climate which might result in rapid depreciation due to rusting. In addition difficulties as regards the provision of suitable labour for maintenance work are advanced.

II. — Progress in all-metal carriage construction.

In judging to what extent the number of metal vehicles has increased since the Madrid Session, 1930, it must be borne in mind that the financial difficulties due to the general economic depression in the world's markets and the decline in traffic have reacted unfavourably upon the rate of progress and the rate of renewal of vehicles.

The following table, taken from the records of the International Railway Congress Association shows the number of all-metal carriages on the 1 January, 1932, as given by the individual railway administrations, as a percentage of the total number of carriages. So far as the data supplied allowed, the total number of vehicles and the numerical additions as compared with 1930, have been given at the same time. The numbers for the increases in metal carriages are inserted within brackets.

Germany :			
German State Railways	17.0 %	12 960	(2 704)
Argentine :			
Central Argentine Railway	22.0 %		
Cordoba Central Ry.	12.5 %		
Belgium :			
Belgian National Railway Co. . .	0.3 %	38	(20)
China :			
South Manchuria Railway	31.5 %		
Egypt :			
State Railways . .	20.5 %	326	(157)
Spain :			
North of Spain Rys.	5.0 %	96	(43)
U. S. A. :			
Baltimore and Ohio Railroad	51.0 %		
Delaware and Hudson Company . .	10.0 %		
New York Central Railroad	100.0 %		
Norfolk and Western Railway . .	60.0 %		
Pennsylvania Railroad	100.0 %		
Reading Company .	90.0 %		
Wabash Railway . .	38.0 %		
France, Algeria and Tunis :			
French State Rys .	17.0 %	1 266	(737)
Alsace - Lorraine Rys.	1.9 %	65	(45)
Est Railway . . .	2.0 %	76	(56)
Midi Railway . .	9.0 %	200	
Nord Railway . .	8.1 %	412	(235)
Paris-Orleans Ry. .	5.0 %	206	(26)

Paris-Lyons-Mediterranean Ry. . .	11.0 %	899	(509)
French Main Lines (Post office) . .	51.0 %	462	(285)
Great Britain, Northern Ireland, India, Dominions and Colonies :			
London Midland and Scottish Railway .	2.7 %		
London and North Eastern Railway .	1.0 %		
Metropolitan District and London Electric Railways.	89.3 %		
Gold Coast Government Railways . .	14.4 %		
Nigerian Government Railways .	16.0 %		
Sudan Government Railways	17.0 %		
New South Wales Government Rys :			
a) Electric motor coaches . .	67.0 %		
b) All passenger coaches . .	22.0 %		
Canadian National Railways	31.6 %		
Canadian Pacific Ry.	26.0 %		
Eastern Bengal Ry..	0.6 %		
East Indian Ry. . .	4.6 %		
Great Indian Peninsula Railway . .	8.0 %		
Italy :			
State Railways . .	23.7 %	1 942	(642)
Società Trazione Elettrica Lombarda		22	(22)
Nord-Milano Ry. .	8.0 %	28	(28)
Japan :			
Japanese Government Railways .	19.0 %		
Corean (Chosen) Government Railways	3.0 %		
Luxemburg :			
Prince Henri Ry. .	16.8 %	22	(22)
Holland :			
Netherlands Railways	7.2 %	257	(133)
Dutch East Indies State Rys. and Tramways . . .	3.2 %		
Poland :			
State Railways . .	5.0 %	658	(648)
Portugal and Colonies :			
Laurenço - Marquès Railway and Port.	80.0 %		
Sweden :			
State Railways . .	10.0 %	of the bogie carriages.	
Switzerland :			
Federal Railways .	7.0 %	242	(218)
Rhætic Ry. . . .	12.6 %	25	(25)
Jugoslavia :			
State Railways . .	4.0 %	85	(85)

In addition large numbers of carriages were, on the 1 January, 1932, either under construction or under consideration by many of the railway companies. It can be concluded therefore, that in spite of all existing difficulties very appreciable progress has been made in all-metal carriage construction.

Since the Madrid Congress little fundamental change is to be noted in the methods of all-metal construction. The railways who, prior to 1930, had developed special designs for all-metal construction have in general retained the same methods. Those railways who have gone over to all-metal carriage building since that time have generally followed the existing methods.

The majority of these vehicles are carried on bogies, have either side or centre corridors with vestibules at both ends, in which are the entrance doors. Some of the bogie carriages have been built with side entrances.

In the majority of cases of suburban carriages the bodies are divided into a small number of large compartments, to which access is obtained through vestibules arranged along the coach, and provided with large single or double doors, which are sometimes worked automatically.

The general tendency is to profit from the advantages of metal construction by building the carriages longer and increasing the internal dimensions of the compartments in order to provide greater comfort for the passengers. The length of sleeping and dining cars, as well as other types is 22.20 m. (72 ft. 10 in.) or just under. The third class compartments are 1 540, 1 550, 1 600, 1 610 tot 1 690 mm. (5 ft. 5/8 in., 5 ft. 3 in., 5 ft. 3 13/32 in. to 5 ft. 6 9/16 in.) between partitions measured on the longitudinal centre line.

The method of construction in which a body with its own light framing was carried on an undercarriage with fish bellied main members, this frame absorbing all vertical and longitudinal stresses and carrying the load, is being abandoned progressively, as it means heavier weights.

The method preferred in the case of all-metal construction is that in which the body framing and the underframe are combined and in which also the body sides and framing take their share in the strength of the vehicle, as a single structure is obtained in this way. In building carriage bodies as box girders the following three types of construction are used :

— The « tubular » type, in which the body sides, floor, and roof form a kind of tubular girder, all parts of which assist in withstanding the efforts developed in the vehicle. The tubular girder is generally strengthened by transverse rings but, properly speaking, it has no separate body framing.

— The type using a body framing in which the forces are taken up chiefly by certain members which form a very strong horizontal trellis girder — the underframe — and two vertical lattice girders — the body sides — which are crossbraced by the roof carlines and the cross partitions. The outer body sheets also assist in preventing the deformation of the structure as a whole and in resisting the vertical forces.

— The « mixed » type of construction in which the body framing has to transmit the efforts continuously; the outer body panels, or part of them, are called upon to a greater extent to resist the moments resulting from vertical stresses.

Carriages with body framing are built with end doors as well as with side doors.

In carriages for main line service, the problem of the lattice girders for the side walls has been solved by the various railway companies in a practically uniform manner: the side pillars, of Z, L or U bars or of pressed sheets, are attached to the sole bars of the frame at the bottom, and to the cantrails at the top.

More variations are found in the arrangement of suburban carriages on account of the necessary provision of larger side door openings and steps. The door openings are strengthened by a robust frame. The sole bars are built up either of two rolled sections, one behind the other and fastened together in such a way as to provide space for the steps, or these members are set in relatively to the body sides, or they are interrupted at the door openings only, or bent in to the inside.

In place of the clerestory roof formerly used in steel stock, an elliptical roof is now frequently used to increase the strength of the body framing as a whole and to diminish the cost of construction and of maintenance of the roofs.

Special progress has been made towards meeting the demand of many administrations for increased strength against telescoping and the consequent increase in safety in case of accident. Heavier sheets up to 6 mm. (1/4 inch) thick are used for the body ends, or heavier corner and door pillars carried by the headstocks and fastened to the cantrails, which are strengthened by a suitably crossbraced structure. The corn-

er and door pillars are sometimes also made in box section form.

Trials being made, with extra light vehicles for express and ordinary passenger trains, with the object of obtaining greater speed, may also be mentioned. It has been found possible to reduce the weight of a third class fast train carriage from 47 to 36.5 t. (46.3 to 35.9 Engl. tons) and thereby the weight per seat from 587 to 456 kgr. (1 292 to 1 004 lb.) without reducing the space provided nor the strength of the vehicle against shock. In the case of ordinary passenger train stock, the weights were decreased from about 36 t. to 32 t. (35.4 to 31.5 Engl. tons) and as a consequence the weight per seat from 430 to 381 kgr. (946 to 838 lb.).

Specially light designs have been developed for rail motor cars with Diesel or petrol engines, or with steam propulsion, for main and branch lines. The 4-wheeled and 6-wheeled carriages introduced have specially rounded front ends to reduce wind resistance, in order to improve the efficiency of the limited engine power and to obtain the maximum speeds.

The weight per seat has been reduced to as little as 200 kgr. (440 lb.) in trailers for use with this kind of rail car.

The considerable weight reductions obtained by the constructional methods just mentioned are to be attributed to the successful application of high-quality steels and the use of welding.

It should be noted, in addition, that several railway administrations are giving much attention to the standardisation of the so-called rail-autobus, built on automobile lines.

A new type of carriage of the low double-deck type to carry 120 passengers is also worthy of mention.

Some administrations have also built experimental carriages embodying an extensive use of aluminium, and are trying them out in service.

III. — Materials for the construction of all-metal coaches.

a) *Materials other than light metals and alloys.*

Mild steel, as in the past, is still used in the construction of the more recent all-steel wagons to the greatest possible extent. A number of railway administrations have however already substituted alloy steels with tensile strengths of 52 to 64 kgr./mm² (33.0 to 40.6 Engl. tons per sq. inch) (e. g. copper-chromium-molybdenum steel). These steels, the physical properties of which correspond closely to those of silicon-steel, are capable of being welded easily.

1. Several tendencies, sometimes completely opposed, are still noticed as regards the designs of *frames and body framing* of coaches built since 1930.

Some companies still use extensively *plain sheets and standard rolled sections* in order to get the simplest possible constructional and maintenance methods.

Another group of railways uses on the other hand *bent and pressed sheets* in order to obtain a certain reduction in weight.

A third group again has recently adopted the method of using plain sheets and *special thin rolled sections*, besides the pressed steel parts, in order to obtain the advantage both of simple constructional methods and light weight.

Many of the steels used contain 0.2 to 0.5 % of copper in order to reduce rusting.

Castings are still used to a great extent for certain parts (body bolsters, draw and buffing gear, bearing spring brackets, underframe parts, and body side details) which would be difficult to produce as pressings. Efforts to manufacture these parts by welding and obtain considerably lighter parts are becoming more and more evident.

2. *Bogie* frames are built up in the

usual way of rolled sections, pressings, and also steel castings.

3. The *body sides and roof are covered* to the outside with steel sheets. High-grade and copper bearing steels are being increasingly used.

Lead covered sheets and soft annealed steel sheets are also used.

4. In several types of coach, the body sides and roof are generally lined out with thin metal sheets, which are as a rule only painted in the third class compartments, while in the other classes they are covered with linoleum, leather cloth, or similar materials. The steel sheets are sometimes simply painted or sprayed with cellulose lacquer and varnish.

Many administrations, however, continue to use wood for the interior lining (plywood), as they consider that a better appearance is obtained in this way, as well as greater insulation against changes in temperature and against noises.

5. The *cross partitions* are built up of metal sheet or of wood. Metal partitions covered with wood are also used. In this way the body framing can be made stiffer, and the more pleasing effect of wood lining retained. In the event of an accident, the danger through the wood splintering is removed by using plywood.

6. The *floors* are usually built up of galvanised corrugated or chequered steel sheets, covered with a layer of a mixture of cement and cork, wood or magnesium. Double floors, the top of wood and the under floor of metal plate, are used and also top boards covered with cork slabs.

A number of administrations, however, remain true to the old type of floor consisting of a double layer of floor board. Good insulation against abnormal temperatures and undue noise is claimed for this system.

7. With regard to heat insulation, there have been few developments. In most cases the air space between the inner and outer panelling, through which there is some circulation of air, is considered to provide sufficient insulation.

In countries with specially hot or cold climates, the inner faces of the outer body sheeting and the outer faces of the inside lining are treated with special insulating material (Salamander, Celotex, Sundeala, Feutrisol, felt, cork, Alfol, etc.).

Special screens are also provided as a protection against sunshine.

b) Light metals and alloys.

Light metals and alloys are used to an increasing extent for the interior fittings. The cross partitions and the interior linings of the sides and roof, as well as the outer roof, the entrance and inside doors have already been made frequently of light metal (e. g. aluminium, duralumin, alpax, lautal) than not.

Coaches have even already been built entirely of light metals.

The use of light metals in the main structural parts of rolling stock is however so limited and the experimental period so short that satisfactory conclusions on this question cannot yet be drawn.

Generally speaking, light metals have, up to the present, been used in a rather cautious way for important underframe and body framing members.

The following reasons are given :

Regardless of the high cost of the material, it must be borne in mind, when proportioning the constructional parts, that the modulus of elasticity of a light metal, and thereby its resistance to buckling, is only one third that of steel. These parts must, therefore, be given amply large sections when light constructional materials are used.

The elongation coefficient on the other hand is double that of steel. The large difference between the two materials must be specially taken into account when dealing with a composite

structure of steel and light alloy. Difficulties have already arisen in hot weather in cases in which light metal roofs and sides were carried on a steel framing.

Special attention must also be paid to the questions of the fatigue and ageing of these materials.

In order to prevent corrosion at the joints between light and other metals, red lead paint or cloth soaked in red lead is inserted between the surfaces in contact. Layers of felt and teak packing have also been used.

In addition the light metals and especially the light alloys, which are preferred on account of their greater strength, are very sensitive to moisture. Precautionary measures against oxidation such as painting should therefore be taken.

The weight reductions due to the use of light metals are quite remarkable. They amount to 14, 20, and in some cases to as much as 40 % as compared with similar steel structures. Against this, increased costs from 20 to 60 % have to be allowed for.

There are, however, insufficient results to justify the drawing of any satisfactory final conclusions on this subject.

IV. — Assembly of details by riveting and by welding.

Riveting is the most widely used method for connecting details of the structure together. Metal screws are also often used at the same time as rivets to assemble light metal or alloy parts among themselves or to other classes of materials.

Countersunk rivets are increasingly used for the outer panelling; smooth body sides are much easier to paint and to clean, and there are fewer points to be attacked by rust. As countersunk rivets are difficult to drive in thin sheet the work may be made easier by using joint strips which, when arranged horizontally, may also act as gutters.

Vertical rows of rivets without outside joints strips have also been used, flat strips, 3 mm. (1/8 inch) thick being spot welded on the inside face of the panelling so as to obtain a sufficient thickness of the metal.

On the other hand, railway administrations are being converted more and more to the welding of joints, sometimes for some unimportant joints only, but also for assembling all the parts.

The following advantages of welding may be mentioned :

1. No reduction of strength through holes in members;

2. Economy of material owing to the better utilisation of rolled sections and sheets;

3. Reduction or elimination of gussets and angle pieces;

4. Replacement of castings by considerably lighter welded parts.

The customary methods of welding in use at the present time [autogenous welding, arc welding, seam, butt, spot] are employed according to requirements and the kind of joint; arc welding is the most extensively employed.

Warping of the members and deformation of the plates can be met by shaping them before welding so as to compensate for any distortion set up during welding, or by using beavy copper plates held up to the work to conduct the heat away rapidly. Welding under water has also been used. Straightening up the parts after welding is also done.

The strength and quality of the welds has not been questioned. By proof load and X-ray tests the freedom of welds from faults has been ascertained.

Although the information as regards the results obtained with all-welded steel carriages is still unimportant, many administrations voice the opinion that welding will successfully replace riveting and will result in a considerable reduction in weight. The general introduction of welding for the majority of vehicles will likely soon bring the cost

of welded vehicles below that of rivetted stock.

The high cost of structural materials in the case of light metals and alloys has made it necessary to bring down to the lowest possible minimum the weight of the various parts. If this principle be also applied in the case of steel construction, and at the same time high-grade steels of high price be less used, all-steel constructions will possibly take the place of light metals and alloys in carriage building. Approximately equal weights, with appreciably smaller production costs, can be obtained in this way, and such all-steel carriages promise to be stronger and have a longer life.

Reductions in weight of from 47 to 37.5 t., i. e. of 20 % or over for the whole vehicle have today been made in fast train coaches of similar types, by this form of steel construction; at the same time reductions in weight in individual parts of up to 27.4 % and more were effected.

B. — Goods wagons.

The following considerations refer to open and covered goods wagons, also to those intended for coal, coke, ore and grain traffic. Steel wagons with wood flooring are included in the all-metal class.

I. — Advantages of all-metal construction for goods wagons.

In the case of goods wagons endeavours are also being made to use all-metal construction more and more, in spite of the special precautions that must be taken to prevent rusting.

The following reasons are put forward by the railway administrations in favour of the *all-metal* type as against that consisting mainly of wood :

Greater strength;
Greater safety in service;
Longer life (up tp 33 %);
Lower maintenance costs;
Shorter time in the shops as the parts are more easily replaced;
The possibility of repairing sections by straightening them or by welding;
Greater loading capacity;
A more satisfactory ratio between the load and tare weights.

Other railway administrations consider the *composite type* in which the frame and the body framing are made of steel and the body of wood, the better for the following reasons :

Better heat insulation;
Greater durability of covered wagons and insufficient ventilation when carrying certain classes of goods;
Possibility of being able to undertake a greater amount of repair work at other than the main shops.

II. — Progress in the use of all-metal construction for goods wagons.

The data collected by the railway companies with regard to the increase in such stock do not allow of any comparisons being made, as similar data was not available in 1930. They show however the growing use of all-metal construction and also the great differences in its practical execution in the various countries.

In Europe covered wagons are almost entirely of composite construction, while open wagons are constructed either in this way or are all-metal. On the other hand it must be noted that in other countries a large proportion of the covered wagons and most open wagons are built wholly in metal. Most of the European administrations however, are so satisfied with all-metal construction for open wagons that in the future it will be employed generally for new vehicles, whereas for covered wagons the composite method is likely to be retained.

In determining the suitability of the two methods, climatic conditions in dif-

ferent countries apparently play a great part.

Special wagons for coal, coke, ore and grain are almost all built entirely of metal.

III. — Methods of construction and materials employed.

Steel in the form of sections, pressings, and plain or corrugated sheets, is used generally for all-metall goods wagons.

In its main features the method of construction is almost universally the same : the underframe and body framing from a girder built up from rolled steel sections and with bent or pressed steel body sheeting.

To avoid any deformations of the underframe through rough shunting the precaution is often taken of building the ends as a very strong box girder. In many cases deep and heavy longitudinals are built up in fish bellied form. Wagons have also been built, however, in which bent and pressed plates were used exclusively for the under frame and body, no separate body framing being used so that the sides make up one solid unit with the underframe. Sole bars built up as welded box girders are also coming into use.

The *floor,* even in all-metal wagons, is usually of wood, as, especially in open trucks, they are not subject to damage through rust and are also convenient when fastening down the wedges used to secure heavy and bulky goods.

The *roofs* of covered metal wagons are made of plain or corrugated metal sheets.

Eight-wheeled wagons are carried on bogies or on independent pairs of wheels.

In order to minimise the *damage caused through rust* in all-metal wagons, copper bearing steels are used both for sections and for sheets. « Armco » iron is also used. Some administrations use galvanized material for the sole bars and headstocks, as well as for the panels.

While a number of railways do not believe in any special painting to prevent rust, others use anti-corrosive paint, black asphalt cement, coal tar colours, or metallic paints. Metal spraying is also employed, though almost always experimentally. The trials of sprayed work have not been completely satisfactory, while the process itself is very expensive.

With reference to heat insulation, no standard methods are followed. The one practised mostly consists in using wood sheetings with an air space between. To avoid sweating, cork spraying is resorted to.

IV. — Assembly of individual parts.

Up to the present the generally accepted method is riveting. The holes are frequently drilled in jigs. On some railways details or the wagon as a whole are welded. Those parts however that must be easily renewed or repaired are secured by rivets or bolts.

In welding all-metal goods wagons it is difficult to avoid deformation of the plates. In spite of this, however, a large number of administrations agree that welding can be employed wherever riveting has been used.

Arc welding as well as autogenous welding is employed.

The saving in weight due to welding is stated to be from 10 to 15 %. It is also pointed out that welding will be dearer if it cannot be done on a wide scale. Whether this is so or not will be much more clearly apparent when welding has been adopted more extensively.

SUMMARY.

As a result of this survey the following summary may be drawn up :

A. — *Passenger carriages.*

1. The favourable results obtained during the last three years with all-metal passenger coaches confirms the summary of the Madrid Congress, wherein the following special advantages were emphasized :

Greater safety in case of accident;
Favourable tare weight of the vehicles;
Possibility of mass production;
Good interior appearance and arrangement.

2. Results so far obtained appear to authorize favourable expectations as regards the life of the vehicles, maintenance costs and redemption of the original capital cost. They justify the expectation that all-metal carriages will prove themselves and produce definite savings, especially in those countries in which the conditions for their use are most favourable.

3. The method of construction in which the underframe and the body framing are built as one unit which absorbs the forces developed as a whole, the weight being reduced at the same time, has given further satisfaction. In all-metal construction this method is used almost exclusively.

4. By the use of high-grade steels and by the substitution of welding for riveting, appreciable savings in weight, as compared with wood or riveted steel carriages, can be effected.

5. The use of light metals and alloys can also reduce the weight appreciably and therefore offers advantages in certain structural parts under specified conditions, in spite of their high price. Conclusive evidence as to their behaviour over a long period of time is not yet available. The Congress recommends the use of these materials to be further investigated.

B. — *Goods wagons.*

1. Metal construction has special advantages over wood for open goods wagons :

Greater strength;
Greater safety in service;
Longer life;
Lower maintenance costs.

2. Under given climatic and operating conditions covered goods wagons, whether of the all-steel type or of composite construction in which the underframe only is all-steel, are used successfully.

3. All-steel construction for special coal, coke, and mineral wagons is advantageous.

4. By substituting welding for riveting, appreciable reductions in weight can be effected.

5. The use of copper bearing steels affords an efficient protection against rust.

SECTION III. — Working.

[656. 223.2]

QUESTION VII:

Allocation of freight rolling stock. Investigation into the turn-round of goods vehicles. Separation of the elements included in it. Methods of reducing the period of turn-round,

by W. F. H. van RYCKEVORSEL,
Special Reporter.

This question has been made the subject of the following three reports :

Report No. 1 (Germany, Denmark, Finland, Great Britain, its Dominions and Colonies, Sweden, America, China, Japan, Norway, Holland and Colonies), by W. F. H. van RYCKEVORSEL (1).

Report No. 2 (Belgium, Spain, France, Italy, Portugal and their Colonies, Luxemburg and Switzerland), by Mr. O. GAEREMYNCK (2).

Report No. 3 (all other countries), by Mr. J. D. DOLINAR (3).

Perusal of these reports has revealed the fact that no divergence of opinion exists between their authors on any essential points, and consequently, to avoid the needless repetition which would ensue if they were discussed separately, they have been condensed into one single report in which the particular opinions of one or other of the Reporters have been specially mentioned where needful.

A. — Allocation of goods stock.

I. — Definition of the problem of allocation.

The monopoly which the railways enjoyed to a greater or less extent before the advent of road competition, and the considerable importance attached in all countries to transportation by rail, has almost everywhere resulted in a legal obligation being laid upon the railways to convey all goods whatsoever, the only exception being where transport involves some danger or where the nature or dimensions of the goods renders conveyance by railway impossible.

In order to carry out this obligation, therefore, the rolling stock department must have at its disposal, at all times, a sufficient number of its own wagons or wagons which have arrived under load from other systems and are available for reloading under the conditions of the exchange agreements.

The periods in which wagons applied for by senders have to be placed at their disposal differs greatly from one system to another. Where no maximum period is laid down the railways are required to furnish the wagons applied for as soon as possible. Applications for wagons must be dealt with in the order they are received, subject to priority being given to livestock, foodstuffs and perishable goods and to coal and goods for export or requiring to be rapidly despatched in the general interest.

During periods of heavy traffic when it is not possible to satisfy all the applications, the wagons still available after providing for the goods entitled to priority are divided proportionally between the various applicants, account

(1) See *Bulletin of the Railway Congress*, May 1932, p. 609.

(2) See *Bulletin of the Railway Congress*, July 1932, p. 1259.

(3) See *Bulletin of the Railway Congress*, October 1932, p. 1911.

being taken of the order in which the applications have been made.

Wagons are to be applied for either verbally, in writing or by telephone or telegraph, certain railways requiring written confirmation of telephonic requests. Applications must stipulate clearly the number and type of wagon desired, the nature and weight of the goods to be forwarded, the time by which the wagons are required and the destination station of the consignment. With a view to avoiding disputes, the applications are generally entered in a special register in the order in which they are received, and senders are not allowed to see what applications have been made by others.

Nearly all railways have reserved the right to select what stock to supply within the limits allowed by the conditions applicable to the rate charged, so that should wagons of the type required not be available or only available in insufficient numbers, the railways may decide either themselves or by agreement with the senders what other kind of stock shall be supplied. Having regard to the serious competition of other means of transport, it is of the greatest importance, when stock differing from that applied for is furnished by the railway without consulting the sender, to see that the rate chargeable is not adversely affected thereby from the sender's point of view.

When orders for wagons are cancelled or when wagons are supplied and not loaded, the majority of railways are entitled to make a charge for non-use or demurrage, and further, several railways require that orders for wagons shall be accompanied by a deposit to cover themselves against non-use of the wagons applied for. Most of the railways, however, only require such deposit in exceptional cases, and others, on which the rule exist, make an exception in favour of senders who have entered into a tonnage agreement.

As regards wagons furnished daily, the information obtained shows that on most railways open wagons are most usually supplied, whilst on the remainder, the covered wagons are the more numerous. Cattle trucks, flat wagons and other types are much less used.

It is also noted that stations can be divided into the three following groups :

1. Predominantly forwarding stations, where the number of wagons of a particular type forwarded, regularly exceeds the number of similar wagons received under load. Such is the case at stations situated in large coalfields and industrial centres and at ports where import traffic predominates in respect of certain goods.

In these cases many railways have been able to schedule a regular flow of the necessary types of wagons, the wagon control office only intervening in order to regulate the supply should it be insufficient or in excess.

2. Predominantly receiving stations, where the wagons received under load are always more numerous than those forwarded.

3. Stations where the numbers of wagons forwarded and received balance each other.

As a general rule, on the various systems, orders for wagons are subject to considerable fluctuations, caused principally by seasonal traffic (such as cereals, beetroots, potatoes, hay, straw, flax, sugar, sugar-cane, peanuts, vegetables, fruit, cocoa, cotton, coal, live stock, motorcars, cement, etc.), shipping delays or trade contingencies. The periods at which these fluctuations occur and also their duration and magnitude differ greatly from one country to another, according to their geographical position, climate and the nature of their products.

II. — Solution of the problem of allocation.

With a view to supplying senders as quickly as possible and at a minimum of cost with empty wagons or wagons available after unloading, the majority of railways have centralised their wagon control organisation.

If the railway system is not too extensive the stations supply the central distributing office direct with statements of what stock they have on hand empty or being unloaded, together with particulars of what stock they require. On the basis of this information the central office allocates the stock, and by telephone or telegraph sends the necessary instructions to the stations concerned for the despatch of empty stock, also advising the stations to which the wagons are forwarded.

In a variant of this system, several stations are grouped together. One of them receives the statements compiled by the others and gets into touch with the central control office, afterwards arranging the allocation in its group.

On more extensive railways the stations, whether grouped or not, are divided into districts and the central control office only functions in order to arrange for a flow of empty wagons from districts having more than they require to those having less. In some cases the districts are again combined into groups.

The stations themselves allocate between the various senders the wagons supplied by the central control office.

In compiling the statement of their wagon position which they supply to the central control office, stations have to distinguish between the different classes and types of wagons and show foreign wagons separately. Mention must also be made of wagons turned out of repair shops and thus available for use, and an indication given of the number of wagons required to be kept in reserve. Having regard to the competition from other means of transport, stations adjacent to ports, industrial centres or large markets, particularly require to have a sufficient reserve of wagons at their disposal in order to meet any sudden increase in the traffic.

Several railways also require their marshalling yards to supply the central control office with an analysis of the composition of trains. Others go still further and require that the statements referred to above shall also indicate the number of wagons loaded and in course of loading, the number furnished the previous day, or which were required but not supplied, also the number of wagons in respect of which unloading is delayed.

The time fixed for the despatch of the wagon position statements from the stations to the distributing offices, whether by the trains specially designated, by written reports or by telephone or telegraph, as also the time of despatch of the orders from the wagon control office, differ greatly from one system to another. It would appear desirable for such times to be so fixed that the wagon control office should be in a position to transmit its orders to the stations at such time that as little delay as possible occurs between their reception and the placing at the loading platforms or the despatch of the wagons.

In order to be in a position to allocate the stock reported as available, between the stations where it is required, with a minimum of cost and, to the extent that the need exists, with a maximum of speed, the central control office should have a complete knowledge of the traffic requirements and of the permanent and temporary flow of loaded wagons. If, for instance, a station is predominantly a receiving point for loaded covered wagons but a predominantly forwarding point for open wagons it may be convenient, so far as the nature of the goods consigned permits, to use covered wagons for goods which otherwise

would require empty open wagons to be sent to the station at the same time as empty covered wagons are being sent therefrom, thus obviating double empty haulage. The movement of empty wagons of the same type in opposite directions should always be avoided, and therefore the wagon control office must be fully acquainted with the running of trains, their load and the time necessary at the various stations for getting wagons into or out of the yards or depots.

Stations which receive orders to despatch empty vehicles must always see that they are forwarded by trains which will convey them to their destination with the minimum of shunting en route and the maximum speed.

It is also desirable to use foreign wagons as far as possible, within the limits of the exchange agreements. A saving is thus effected in empty haulage which is far more costly than the additional wagon-user charge payable and, moreover, the railway's own reserve of wagons is thereby augmented, which gives a further possibility of reducing empty haulage. Many railways, however, do not use foreign stock when there are plenty of their own wagons available. For the reasons explained, this policy does not appear to the reporter to be conducive to economy.

The reserve of each category and type of wagon can also be augmented by reducing to a strict minimum the number of categories and by adopting a standard type for each category, account being taken of the maximum axle-load allowed. All the railways are tending towards this reduction in the number of categories of wagons and the standardisation of types, realising it gradually when acquiring new stock, but the standard types of the various countries are very different in regard to tonnage.

Railways having an interchange of traffic between them could greatly facilitate the exchange of stock and avoid a considerable amount of empty haulage by coming to a mutual agreement in regard to standard types.

As already stated, several railways have found it possible to set up regular currents of empty wagons to large mining districts, industrial centres and sea ports. The advantage of this is not only that wagons can be despatched in accordance with the standing orders as soon as they are free, which accelerates the turn-round of stock, but also that the work of the central control office is considerably lightened thereby, with a consequent saving of staff, whose work is reduced to regulating the flow in cases of insufficiency or excess of supply.

The Belgian Railways have developed this system of standing orders. From a careful analysis of the traffic they have been able to extend it to cover a large number of wagon movements from groups of stations where stock is in excess to others which have a deficiency of the same type of wagon. For each category of wagon, every station has a standing order for the evacuation of wagons on hand to a concentration point, from which they are despatched, partly in accordance with regular schedules and partly by means of regulating currents, to supply a designated distributing station, the latter furnishing the stations in its particular group with the wagons required. The flow of empty wagons is arranged direct from the concentration points to stations where the need therefor is greatest, stations situated on the route of the flow being allowed to take what wagons they require if sufficient are available and apply for the remainder to the concentration point situated in the direction from which the wagons are moving. In the elaboration of the scheme care has to be taken to avoid unnecessary empty haulage and cross haulage and to make the best use possible of the existing trains.

The Netherlands Railways, which

have copied this system from the Belgian National Railway Company, have already applied it to open wagons which represent 46 % of their stock. and are studying the question of its application to other types. In introducing this system for open wagons the Netherlands Railways have at the same time modified their goods train services with the assistance of flow-of-traffic statistics, carefully allowing for the shunting work required at forwarding stations and the times at which the wagons are required at the receiving points. They have by this means considerably accelerated their turn-round of stock, whilst the number of train-kilometres has been appreciably reduced and staff economies effected.

During periods of light traffic a part of the stock becomes unused, and on some railways is stored in special sidings. Generally speaking, however, such wagons are so distributed at stations on the system that directly a recovery of the traffic for which the particular types of wagons on hand are required takes place, they are available for despatch, with a minimum of empty haulage, to stations in need thereof. Opinions are divided as to whether it is preferable to store the newer wagons or the older stock and stock costing the most for maintenance.

The various railways likewise differ on the question as to whether it is desirable or not to possess more wagons than are necessary for normal traffic. Several railways consider it advisable for the stock to exceed the normal requirements by a certain percentage, whilst others are of opinion that recourse should rather be had to a more intensive use of stock during periods of heavy traffic, thereby avoiding additional capital expenditure. The reply to the question is greatly influenced, moreover, by the magnitude of the seasonal fluctuations of traffic.

Divergencies of view also manifest themselves in regard to the inclusion of private owners' wagons in the stock. Certain railways will not admit such wagons, and the majority of systems only encourage their construction for the conveyance of goods requiring special wagons.

It should be borne in mind that the possession of private wagons has the effect of tying their owners to the railway, with the result that traffic is retained which otherwise might be lost to a competitor.

With a view to the economical use of wagons, the majority of railways have so devised their rates as to make it advantageous for senders to make the best possible use of the loading capacity of wagons. A number of railways also encourage, in their rates, the consigning of goods in large quantities or in complete train loads.

Finally, we may note that the allocation of sheets and other loading tackle is based on the same principles as are applied to wagons, sheets on hand being sent to selected depot points. Not all railways have sheets at their disposal, whether belonging to them or hired.

III. — Checking the execution of the allocation orders.

The utility of such check from the point of view of rapidity in the allocation of stock and reduction of the cost connected therewith is recognised by all railways and is carried out in different ways, but the methods employed have the following points in common :

1. A daily check is effected by the control offices.

2. An occasional check is effected at the stations by men specially appointed for the purpose.

The control offices check by means of the statements sent in by stations whether the latter have given effect to the orders for the despatch of wagons

or if they have received the vehicles due to them, and whether empty wagons have been despatched in the trains designated.

Should this not be the case the retention of wagons at the station may be attributed to :

1. Lack of forwarding facilities owing to room not being available on the trains prescribed for the despatch of the wagons, which may be due to there not being a sufficient number of goods trains or to the locomotives used not being powerful enough, or in some cases, to an insufficiency of brake wagons or brakesmen to operate them;

2. Inadequate means for shunting, involving delay in getting the wagons out of the unloading or marshalling sidings for incorporation in the trains;

3. Delay in the unloading of wagons;

4. Incorrect information furnished to the control office by the stations.

The causes under (1) and (2) above should be removed as soon as possible in close collaboration with the goods train running and shunting departments by putting on the necessary additional trains, or increasing the locomotive power, the number of brakesmen, brake-fitted wagons or shunting locomotives as the case may be.

Cause (3) may be temporary, as in the case of strikes at ports or industrial centres, but it may also occur when the arrival of loaded wagons at a station is irregular and uneven, either owing to lack of arrangement between the senders and consignees or by late running of trains. If this cause cannot be removed by a better organisation of the train service or by quickly getting into touch with the senders, the control office must carefully take account of the conditions in the issue of instructions for the supply of stock to such stations.

Should cause (3) operate to such an extent at particluar stations that there is a risk of congestion during busy periods, it may be necessary to consider the advisability of raising the demurrage charges at such stations or even to suspend or reduce the supply of wagons to senders of consignments destined therefor.

When cause (4) is revealed, severe action should be taken against the station at fault, as inaccuracies in the wagon reports cannot be tolerated if efficient allocation is to be achieved.

Checking at irregular intervals by special travelling inspectors is effected by comparison — spot check or otherwise — of the wagon reports received by the control office with the records retained by the stations (census, register of senders' applications, etc.) with a view to seeing whether the reports correspond with the actual position, whether the loading and unloading of wagons, their removal from or incorporation in trains and their transfer to loading and unloading sidings and vice versa, is effected with sufficient despatch, and whether wagons are supplied to senders in the order the applications are received.

In view of the importance which should be attached to this checking, no other than thoroughly competent men should be entrusted therewith.

Railways who allocate either mainly or partially on the basis of standing orders, are in a position to ascertain immediately any deviation of the supply from the normal, as the central control office and the allocating stations concerned receive telephonic or telegraphic advices from the concentration points and the distributing stations at regular times during the day, stating the number of wagons received on each train. Any inadequacy in the flow of empty wagons is thus revealed immediately, enabling the central control office to take steps to remedy the position.

B. — Investigation into the turn-round of wagons.

I. — Definition and methods of calculation.

By « turn-round » (in French « rotation ») is meant the successive phases that occur between two successive loadings of a given wagon. The time occupied in these phases is the turn-round time, and it differs considerably for the various types of wagon of a particular category according to whether it is possible to reload the wagon immediately on the spot or whether it is necessary to send it to another station, or according to whether the loaded and empty journey of the wagon is long or short, etc. All that can be done, therefore, is to calculate the average turn-round time over a given period.

This average, called the turn-round for short, is expressed by the formula $r = \frac{E}{F}$, where E is the number of wagon-days pertaining to all the wagons on the system during the period in question and F the number of wagons supplied to senders during that period.

The value of the turn-round thus ascertained is only for calculating net costs and fixing the rates in proportion thereto, and also for determining the number of wagons by which the stock may require to be increased.

For the allocation of wagons, however, what is required is the turn-round of the wagons available for use, so that E must be adjusted by deducting the number of wagon-days lost during the period under notice owing to wagons being repaired or inspected or to wagons not put into traffic owing to non-use.

Several railways only ascertain the $r = \frac{E}{F}$ turn-round in case of need for one of the reasons indicated, and are of opinion that a properly-applied check on the execution of the wagon allocation orders (as explained in A-III) is sufficient and that the regular ascertainment of the turn-round does not justify its cost.

The majority do not share this view, however, and with the aim of keeping a watch on the economical use of stock they ascertain the turn-round defined secondly above at regular intervals (day, week or month) and also when required by an increase in the traffic.

Further, a careful study of the turn-round and the various elements of which it is composed, makes it possible to judge whether it is necessary to modify the method of allocation in force and introduce any important changes in the running, composition and shunting of trains.

There is no uniformity in the formulæ employed by the various railways for calculating the turn-round. Some include the foreign wagons on their lines whilst others omit them. Most frequently, however, the calculation is only applied to the wagons actually on the system, wagons temporarily on other companies' lines being deducted.

Certain railways arrive at the turn-round by adding together its various elements, i. e., by calculating the average time a wagon is in movement under load and empty and adding thereto the average time spent at stations.

Another method consists of putting a special form on a large number of wagons, the various times at which the successive phases of the turn-round commence and finish being entered thereon. From the data thus obtained an average turn-round is obtained, analysed into all its elements.

In the ascertainment of wagon-days lost owing to non-use a wagon is considered as « surplus » if it has not been used for a certain time (generally 24 hours) after unloading.

The turn-round is either calculated for the whole of the wagons or for each category separately.

II. — Analysis of the elements of which the turn-round is composed.

The turn-round is made up of :

1. The time taken at loading or other sidings in loading the wagons.

2. The time taken at the forwarding station in placing the wagons in the trains.

3. The time taken in hauling the wagons to destination by the appointed trains.

4. The time taken at intermediate stations in transferring wagons from one train to another.

5. The time taken at the destination station in taking wagons off the train and placing them at the unloading place or on private sidings.

6. The time taken at unloading sidings for unloading the wagon and carrying out the formalities connected therewith.

7. The time taken in incorporating the empty wagon in the train by which it has to be forwarded in accordance with the control office's instructions.

8. The time taken in conveying the empty wagon by the appointed trains to the station at which it is to be reloaded.

9. The time taken at intermediate stations as indicated under (4) above.

10. The time taken in getting the wagon to the loading platform or private siding on arrival at the reloading station.

The elements represented by items (1) to (6) constitute the turn-round under load, whilst items (7) to (10) represent the empty turn-round.

The time elements named may be grouped as follows :

a) Items (1) and (6) — for the handling of the wagon on loading, unloading and other sidings, and at forwarding and receiving stations.

b) Items (2), (5), (7) and (10) — for shunting at forwarding and receiving stations.

c) Items (4) and (9) — for train stops at junctions.

d) Items (3) and (8) — for conveyance on trains.

The majority of railways do not calculate the separate elements of the turn-round, whilst a few calculate them only at indefinite periods.

On the Belgian National Railways the central control office ascertains each week groups *a*), *b*), *c*), and *d*) by means of information supplied by the stations, each of which establishes the time in respect of *a*), *b*) or *c*) as the case may be. The central control office calculates the average time per wagon for *a*), *b*) and *c*), then the turn-round *r* and determines the value of *d*) by finding the difference between *r* and the sum of *a*), *b*), and *c*).

The Netherlands Railways, who recognize the value of this calculation and will also partly apply it, consider it sufficient to have *a*), *b*) and *c*) determined by each station daily so far as it is concerned, and for the figures to be checked by travelling inspectors. It is hoped that the stations being thus able to follow daily the variations in the turn-round, they will do all that is possible towards reducing the average time and maintaining it at a low figure.

The daily ascertainment of the average time spent at a station can be arrived at by the formula :

$$\frac{2}{n + n'} \times (24\ s + \Sigma\, nh - \Sigma\, n'h'),$$

n being the number of wagons taken out, h the time of departure of the train, n' and h' the corresponding quantities in respect of arriving trains, and s the number of wagons still in the station at midnight.

III. — Means of reducing the turn-round period.

The means which may be employed for reducing the turn-round can be classified under two categories : permanent

measures, which are therefore applied even at normal times, and temporary measures to which recourse is had when there is a shortage of stock.

Among the permanent measures are :

1. Reduction of the empty journeys referred to under Section II above, items 7 to 10, by,

a) back-loading of foreign stock,

b) reducing to a minimum the number of categories of wagons, and establishment of a standard type in each category, designed for the maximum axle-load allowed.

c) supplying senders, if possible, with wagons of other categories than those asked for, if the forwarding of empty wagons of the desired categories can thereby be avoided.

d) the devising of rate (charging) conditions to encourage an optimum use of wagon capacity, with a consequent reduction of the number of wagons necessary and an increase in the wagon reserve.

2. Reduction of the time referred to in Section II above, items 2, 5, 7 and 10, by suitable re-arrangement of the train and shunting services, in close collaboration with the wagon control office, and by the establishment of standing orders for the despatch of empty wagons to stations continually in need of a supply.

3. Reduction of the time referred to in Section II above, items 4 and 9, by forwarding wagons on through trains wherever possible, and encouraging by rate reductions the consignment of goods in large quantities or in complete train loads.

4. Reductions of the time referred to in Section II above, items 3 and 8, by increasing the speed of trains after equipping the stock with the continuous brake.

5. Reduction of the time referred to in Section II above, item 6, by advising consignees immediately of the arrival of loaded wagons, and using self-discharging wagons between suitable stations.

Among the temporary measures applied by the majority of railways during shortage of stock, may be noted :

1. Running special trains;

2. Augmenting the shunting service;

3. Extension of working hours in the wagon control offices, stations, goods offices and sheds, and the introduction of a night and Sunday service;

4. Closer checking of wagon use;

5. More frequent supplying and clearing of the loading and unloading sidings;

6. Sending documents in advance;

7. Increasing the demurrage rates.

Summary.

1. Having regard to the severe competition set up by other means of transport, care should be taken in any well-organised system of wagon allocation to :

a) Supply wagons as quickly as possible in the order they are applied for;

b) Maintain a sufficient reserve of wagons at ports, industrial centres and markets, to meet straight way all contingencies.

c) Avoid senders being kept waiting too long for the wagons they have applied for, even during busy periods (seasonal traffic, etc.).

d) Simplify as much as possible the formalities to be complied with by senders when applying for wagons, without permitting senders to know each others' requirements.

e) Apply with the greatest circumspection charges such as for demurrage and for non-use, deposits, etc., likely to irritate traders and alienate their custom.

f) Comply as far as possible with senders' requirements in supplying wagons, the choice being generally left to the

railway within the limits of the rate conditions. If the type of wagon required is not on the spot and the railway substitutes another type, the trader should not suffer any disadvantage thereby in the matter of the carriage rate charged.

2. With a view to the economical use of wagons it is desirable :

a) To use foreign wagons at all times whenever possible, within the limits allowed by the exchange agreements. The cost of empty haulage is considerably higher than the additional wagon-user charge payable on back-loaded wagons;

b) That the number of categories of wagons should be reduced to a minimum, and a standard type established for each category, with a tonnage capacity corresponding to the maximum axle-load allowed.

c) That the use of private owners' wagons should be encouraged for all goods which would otherwise require railway-owned wagons deviating from the standard types.

d) That rate reductions should be granted to encourage the loading of wagons to their full capacity.

e) That rates should encourage the consignment of goods in large quantities or in train loads.

3. With the object of enabling a rapid and economical allocation of stock to be effected and of ensuring accurate and prompt execution of the wagon control instructions, it is necessary that :

a) Reports of wagons on hand and needed should arrive at the control offices at such time as will enable the latter to so issue their instructions to the stations that the least possible time elapses between the receipt of the instructions and the despatch of the wagons.

b) The central control office and subsidiary allocating centres should keep in touch with each other by telegraph or telephone.

c) The wagon control staff should be well acquainted with the requirements of traffic and the running of trains and alterations therein, and should keep in close collaboration with the goods train and shunting departments so as to obtain prompt execution of all needful operations with a view to speeding up the turn-round of stock.

d) The wagon reports furnished and the execution of the wagon control's instructions should be regularly checked by competent inspectors.

e) Standing orders should wherever possible be elaborated for the despatch of empty wagons to stations continually in need of supplies.

[656. 212. 6 & 656. 225]

QUESTION VIII :

Organisation for carrying small consignments of goods and the most suitable methods for their delivery with the least delay. Use and selection of fixed and mechanical transhipping plants,

by Mr. HAUTERRE,

Special Reporter.

CONTENTS.

Introduction.

Chapter I. — Considerations affecting both fast and ordinary traffic.

Chapter II. — Organisation of fast traffic.

Chapter III. — Organisation of ordinary parcels traffic.

Chapter IV. — Handling appliances used in the conveyance of parcels.

Chapter V. — Résumé and summaries.

Introduction.

The above question has formed the subject of three reports as under:

Report No. 1 (Belgium, France, Spain, Netherlands, Portugal and Colonies, Switzerland, Denmark, Finland, Luxemburg, Norway and Sweden), by Messrs. HAUTERRE and MERMONT (1);

Report No. 2 (all countries except America, Great Britain with its Dominions and Colonies, China, Japan and the countries dealt with in Report No. 1), by Mr. C. FETTARAPPA (2);

Report No. 3 (America, Great Britain with its Dominions and Colonies, China and Japan), by Mr. E. MINSART (3).

The object of this special report is to summarise briefly the above-mentioned reports, and to set forth the conclusions to be drawn from the enquiry as a whole.

Messrs. FETTARAPPA and MINSART were good enough to follow the plan of the questionnaire drawn up after a preliminary exchange of views and as their conclusions were like those of the report prepared by the writer in collaboration with Mr. MERMONT, the compilation of this special report, in which no distinction will be made between the conclusions of the several reporters, has been greatly facilitated.

Considerations affecting both fast and ordinary traffic have been grouped in one chapter and questions relating to the organisation of *fast* and *ordinary* traffic respectively then dealt with separately, a special chapter being devoted to handling appliances used in course of transport.

Finally, in the summaries, an indication has been given of the reporters' views as to the direction in which the Railways' efforts should be directed in order to improve the transport of parcels.

---

(1) *Bulletin of the Railway Congress*, June 1932, p. 907.

(2) *Bulletin of the Railway Congress*, Mai 1932, p. 621.

(3) *Bulletin of the Railway Congress*, September 1932, p. 1777.

CHAPTER I.

Considerations affecting both fast and ordinary traffic.

1. — *Definition of the term « Parcels ».*

According to the different countries, and even from one Railway Administration to another, consignments considered as parcels vary fairly considerably.

This is mainly the result of charging considerations and the diversity of the weight limits and cubic dimensions allowed.

Without repeating the numerous examples cited by Messrs. Fettarappa and Minsart in their reports, we will simply point out that while on certain systems the maximum weight of a parcel is definitely laid down (250 kgr. [550 lb.] for instance), on others it is simply specified that parcels must be packages which can be « easily loaded ».

For the special purpose of this enquiry, however, it will be convenient to adopt the following definition which is, moreover, common to all the replies received: a « parcel » is a package which may be handed in for conveyance without any previous notification and the handling of which falls on the railway.

2. — *Importance of parcels traffic.*

For the reasons which have just been indicated, and having regard particularly to the diversity of the weight and volume limits laid down by the various systems, a notable variation is seen in the ratios between the weight of goods forwarded as parcels and the total tonnage of goods carried over the lines of each Administration.

Mr. Fettarappa estimates that this proportion varies from about 2.5 % (German State Railways) to 10 % (Jugoslav Railways), while Mr. Minsart indicates a proportion varying, from 2 to 5 %.

Taking as a rough estimate an average proportion of 5 to 6 %, it will be seen that the parcels traffic is relatively small as compared with that in wagon-loads. It should be remembered, however, that the parcels are generally highly rated (4 to 5 times as high as wagon loads and even higher in a number of instances) and that, consequently, the corresponding receipts are far from being negligible. On the other hand, owing to the work and other factors connected with such traffic (labelling, entering up, handling, transhipment, risk of loss or damage, low wagon-loading ratio, etc.) the net cost of transport per ton of parcels traffic is much higher than the cost per ton of wagon-load traffic.

Be that as it may, the conveyance of parcels constitutes an important and complicated branch of the traffic organisation and merits the unremitted attention of Railway Administrations.

3. — *Time « en route ».*

On the systems of the countries dealt with in reports Nos. 1 and 2, the delivery periods are determined by a fixed scale according to the distance to be travelled, i. e., one day for every *n* kilometres or part thereof. The value of *n* seldom exceeds 300 km. (186 miles) for fast traffic and 100 km. (62 miles) for slow traffic, in addition to which the railway is also allowed a certain time for despatch and delivery.

Some countries, however, such as Spain, France and Portugal, fix their « fast » delivery periods in accordance with the scheduled running of the trains by which parcels should be conveyed. These trains are determined according to the time at which the packages have to be handed in and the consignment has to be delivered to the consignee a given number of hours after the arrival of the last stated train.

The penalties laid down in the event of the stated times being exceeded

consist of the payment of compensation, which may be fixed (total or partial refund of the charges — charges reduced from the « fast » to the ordinary rates) or may represent the actual damages suffered by the trader.

On the other hand, on the majority of the systems of the countries covered by report No. 3, no stipulation is made as a rule in regard to time, the Companies being under obligation to provide reasonable facilities and to convey all consignments within a reasonable period. When the normal period is exceeded or when, in exceptional cases, times are published and not adhered to, the Railway is liable for any depreciation of the goods but not for other damages.

Whatever system is in operation, there is one factor which, more than penalties, gives an ever-increasing urge for the railways to keep within whatever times it has been able to fix, and that is the competition of road transport. Parcels traffic is liable to fall an easy prey to road transport undertakings, and one of the most effective means of retaining its traffic which a railway company can employ is to increase the speed of conveyance.

4. — *Acceptance of traffic. Facilities offered to users.*

Parcels are accepted at all stations open to such traffic, the goods being handed in by the sender at depots and points determined by the Administrations in accordance with their respective internal regulations and local conditions.

In order to offer the utmost convenience to the public, the Railways have in the majority of big towns opened depots which are either managed by themselves or by outside firms, and at which the senders are offered the same facilities as at the stations. These depots are visited by vans which convey the consignments to the stations, thus relieving senders of that necessity, but as a rule the system is not conducive to speedy conveyance, as unless the depot is large enough to justify frequent clearings, the goods are removed only once or twice daily, and cannot therefore be despatched by all the trains available, which may be very undesirable, particularly in the case of « fast » goods.

In certain important commercial centres not only are there depots or receiving offices, but auxiliary stations have been opened connected by rail or lorry with the central station. Such stations ensure more direct connection between the senders of goods and the consignees.

In the United States the « Terminal Companies » operate such stations situated at different points in several industrial towns, ordinary consignments being accepted for conveyance to any rail point in the country. The goods are conveyed to the departure station either by rail or road, but the use of motor lorries is rapidly increasing, owing to the fact that often as much as 24 hours is saved thereby at the despatching end. The auxiliary stations are consequently becoming nothing more than receiving offices and offer the same advantages.

As an example of auxiliary stations may be indicated those of the German State Railways (6 at Berlin, situated on the borders of the business quarters) and those of the Italian State Railways (5 at Milan, in various outlying parts of the town).

The Railway Companies have also organised cartage collection services in the big towns. These are owned by the Companies and are either operated by them or else leased to other undertakings.

In the United States of America the whole of the express parcels traffic is worked by a single Company : « The American Railway Express Company » which undertakes the collection and delivery of parcels and also their conveyance from one point to another.

As a rule, the sender makes a telephonic or written request for a call to

be made at his premises, but in some cases regular calls are made, so arranged that the goods are brought to the forwarding stations in time for the proper train to be used. Attention is also drawn to the interesting practice of making daily calls at the premises of regular senders.

Mr. MINSART points out in his report that one railway has instituted regular daily services for collection and delivery in many rural districts, irrespective of what traffic is offered. These radiate round a main station, stopping at the small stations in their area and collecting therefrom all parcels handed in for passenger (express) or fast goods train conveyance. If the traffic can be conveyed more rapidly thereby, the lorries also deliver to the stations in their area all express parcels that they have been able to collect for despatch by rail. The ramifications of these collection and delivery services attached to a main station are being progressively extended and the final objective is to make them into a network covering all the rural districts throughout the part of the country served by the railway, and connecting up the towns and villages not served by rail.

The various replies received on the subject of collection and delivery services shew that on the whole the services are poorly patronised. This is no doubt due to the fact that most of the traders possess their own vehicles and drivers, for other purposes, and find it advantageous to use them for doing their own cartage to and from the railway.

Parcels are generally accepted every day (excluding Sundays and general holidays for ordinary goods trains) and for any destination whatsoever.

The acceptance of traffic every other day for particular directions might be advantageous from the point of view of the economical use of stock and the making up of goods wagons containing consignments for distant destinations, thus saving intermediate transhipment, and this method has been applied on a certain number of systems, but Mr. MINSART states that it has often been given up following unsuccessful trials. Mr. FETTARAPPA, on the other hand, reports that it is still in operation on the Italian Railways but only in a few important districts and by arrangement with certain firms.

On the French Railways, through « ordinary parcels » services on fixed days have been inroduced on particular routes, with increasingly satisfactory results. As an instance, the results obtained on the French Est Railway for the first six months of 1932 may be given:

January	8	services	53	wagons. . .	195.4 t.	(192.3	Engl. tons).
February	31	»	256	» . . .	764.9 t.	(752.8	»).
March	91	»	1 090	» . . .	3 196.5 t.	(3 146.0	»).
April	91	»	1 247	» . . .	3 467.9 t.	(3 413.1	»).
May	86	»	1 186	» . . .	3 200.2 t.	(3 149.6	»).

Finally, the interesting results obtained through groupage agencies may be described. These agencies undertake the transport of merchandise between two particular points such as two big towns. They collect the goods from the senders with whom they have been able to come to an arrangement, and they offer the advantage from the point of view of the railway company of being a single sender. They make up full wagon loads, which means that the handling is done by them, and the railway can in consequence effect appreciable economies and is able to grant reduced rates which enables the agen-

cies in turn to offer their clients lower charges than those made by their road transport competitors.

5. — *Formalities in connection with the despatch of goods.*

When a consignment of goods is handed in to the railway it must be checked, i. e., the description of the goods and the number and weight of the packages as entered by the sender on the consignment note must be verified. The sender is as a rule responsible for labelling the goods with the address of the consignee. Certain exceptions (in England principally) are allowed to this rule in the case of consignments consisting of a large number of packages from a single sender to a single consignee.

Is this labelling adequate ? Certain railways, such as the Swiss Federal Railways, the Swedish State Railways and the Finnish State Railways, are satisfied that this label affixed by the sender is sufficient. Other railways consider it necessary themselves to undertake the labelling of the packages, indicating the name of the destination station and giving the route to be followed if occasion demands.

Labelling by the consignor saves time and labour, but it is more reliable and more conducive to the accurate forwarding of traffic when done by the railway. In the opinion of the reporters, the necessity for careful labelling is especially felt in express traffic, as owing to the large number of packages conveyed in a single wagon and the short time available for dealing with them it is usually impossible to check the articles with their respective invoices, and consequently reliance must be placed upon the labels.

The most logical solution of the problem of labelling by the railway would be, perhaps, to discriminate between those packages requiring no intermediate handling and those requirinag transhipment, instead of blindly following a uniform rule. It is obvious, for example, that if a wagon full of goods leaves a big station daily for a single destination it is not essential for the station to label the packages.

As reported by Mr. Minsart, a few companies use labels of different colours to distinguish between « Carriage paid » and « Carriage forward » parcels, but it does not appear that this practice is of very great value.

Wagons containing parcels for various destinations are usually labelled, several railways using different labels from those affixed to wagons fully loaded for a single destination, the contents of which are handled by the trader. These labels are distinguishable either by their colours, dimensions, or printed particulars shewn thereon which indicate the purpose of the wagon and often the trains on which it should travel.

In the reporters' view such differentiation appears to be highly desirable and most useful, as it clearly indicates the « various destination » wagons and makes it possible for:

— the shunters to place these wagons easily in their proper position in the trains, and to get them expeditiously to the unloading bays at the destination or tranship station;

— the loaders to pick out rapidly on the trains stopping at the station, the various wagons on which goods require loading or unloading.

Generally speaking, the Railway Administrations check the weight of packages accepted for conveyance, even when the sender is obliged to declare the weight on the consignment note. Weighing represents a not inconsiderable loss of time during operations at departure, and it is therefore of great advantage at busy stations to have a number of weighing-machines, preferably automatic, placed at the most convenient points (at Halle, in Germany,

goods come in by 21 doors each of which has an automatic weighing-machine placed nearby). In the United States, numerous weighing-machines with automatic registration are utilised.

Another interesting practice is the conclusion of the « Weight agreements » in the United States, whereby the railway does not check the weights of packages handed in by senders with whom duly executed contracts have been made, under which the stated weight is accepted as correct. Periodical checks are carried out to see that the agreement is being properly observed.

The packages are handed in at the same time as the consignment notes, and the system of registration of consignments varies from one railway to another.

As an example of the modern organisation of charging operations the writer would draw attention, with Mr. FETTARAPPA, to the Halle station where at each receiving office there are large racks containing metal plates equal in number to the destination stations of traffic forwarded from that station (at Halle each rack contains 4 000 plates). These plates bear, in relief print, the basic parcels rates for each 10 kgr. up to 400 kgr. (22 up to 880 lbs.) for each destination station, the latter being indicated on the folded-over edge visible from the outside of the rack. A package being received, the clerk takes from the rack the plate corresponding to the destination required and with a small printing machine stamps on the top of the consignment note the particulars on the plate, which thus acts as a stereotype. The charging clerk therefore has only to mark the charge for the weight of the goods as previously verified on the automatic weighing-machine.

Such a system necessitates fairly costly equipment, and could therefore only be applied at very large stations and in countries where the rates for the conveyance of parcels are simple and on uniform bases.

The office work at the forwarding station must be organised so that the documents are always ready in sufficient time not to delay the despatch of the goods.

6. — *Steps taken to simplify formalities.*

The railway usually has to supply the sender with a receipt, which in some countries must shew the charges made. In other countries (such as Portugal, Sweden and Denmark) the charge is not calculated on acceptance if the goods are sent carriage forward. In this manner the sender does not spend so much time in formalities. In practice, even in those countries where the company is obliged to mark the charges on the receipt, the time gained is not always very great, as many senders do not wait for the receipt, but receive it later.

Other and more effective measures have been adopted in certain special cases to simplify the formalities at despatch. The following may be quoted :

Post parcels. — The charges for these are based on weight graduations, irrespective of length of journey. The customer pays the carriage when he obtains the postal voucher, and his receipt is handed to him as soon as the package is accepted.

Express parcels. — These are consigned in a similar manner to passengers' luggage, with a minimum of formalities at despatch.

In the case of certain articles, direct transference by the sender from road to railway vehicle is permitted, as for instance in the case of fresh fish when the harbour sidings are situated some considerable distance away from the despatch shed. Checking and particularly weighing are in these cases difficult; all that can be done is to make a spot check at the departure or arrival station.

7. — *Procedure at the arrival station.*

Immediately after the unloading of the goods, they must be identified, that is to say, compared with the invoices. After this, the documents are sent to the rates office where the charges are checked or ascertained, entered, and the consignees notified.

The goods themselves are sorted out in the arrival shed and kept ready for the consignee. In some localities of sufficient importance, the railway has established delivery services which are generally made greater use of than the collection services.

Some administrations arrange, on request, for express delivery to the customer's premises, for which a special charge is made. In such cases the goods are delivered a few hours after their arrival at the station.

If delivery has to be taken at the station, the consignee is advised of their arrival by letter, or, more often, by telephone or messenger.

CHAPTER II.

Organisation of fast traffic.

8. — *Trains used for the conveyance of « fast » parcels* (1).

« Fast » parcels are chiefly conveyed by passenger trains. The fastest trains are not used as a rule owing to the delay occasioned by handling of goods at the stopping points, but the ever-increasing demand for speedier conveyance has in certain cases led to the use of these train for perishable traffic such as fish.

It is therefore by slow (stopping) passenger trains that « fast » traffic is generally conveyed, thereby often diminishing their effective speed, which is one reason why such trains are less and less used by passengers on branch lines.

On the more important lines, the necessity exists to maintain a satisfactory effective speed and absolute regularity of running for stopping trains. These trains consequently are not used for parcels traffic or only to a limited extent so that their running shall not be upset by the often daily fluctuation in goods traffic, the parcels service being transferred to suitably-timed goods trains.

Even if timed at low speeds, goods trains may provide quicker transit than slow passenger trains, the timing of which is subordinated to suit the needs of the passengers. Thus, on certain sections of a main line, the slow passenger train service at night is discontinued whereas a goods train, although slow, is able to continue its journey.

On lines of medium importance the ordinary goods trains may be used, particularly on feeder sections to the main lines. On the latter, however, the necessity is often felt to run trains exclusively for « fast » traffic.

The conditions under which these trains run are that they shall start after a certain hour and arrive at their destination before a certain hour, such being the case with trains of foodstuffs for the big consuming centres. Since senders always ask for their goods to leave as late as possible and consignees desire to receive them as early as possible, these trains are often run at a speed comparable with that of express and « fast » passenger trains.

9. — *Wagons used for « fast » goods.*

The luggage vans of passenger trains are often used for « fast » goods but in order to avoid transhipment and its inconveniences at terminal stations where passenger trains inter-connect, other vehicles are used for the conveyance of express parcels.

These wagons have a clearly *defined purpose* which is brought to the knowledge of those concerned by special instructions, drawn up after careful con-

(1) Colis grande vitesse.

sideration of the flow of traffic and with the predominant aim of avoiding transhipments which occasion loss of time, incur handling costs and increase risk of loss or damage.

Let us take a station G^1 situated on a section of line A B and a station G^2 situated on another section of line M N.

In accordance with the amount, regularity and distribution of the traffic, a « fast » parcel forwarded from station G^1 to station G^2 may require to be loaded in one or other of the following categories of wagon :

Reserved = generally leaving station G^1 sealed and not requiring any handling operations en route. This reserved wagon may be *regular* or *occasional* according to whether the traffic requires it daily or only on certain days.

Distributor = travelling direct from station G^1 to M, distributing parcels at stations on the section M N. As in the case of the reserved wagon, this distributor vehicle may be *regular* or *occasional* as required.

Collector = collecting parcels from the section A B and proceeding direct to station G^2. The collectors are generally *regular*, as the running of *occasional* collectors is impracticable owing to the difficulty of liaison between the stations with the object of combining their loads.

Collector-distributor = collecting goods on the section A B and distributing them to stations on the M N section.

The four varieties of wagon just described are generally found on all large Railway Companies, designated by various terms such as :— « station », « zone », « tranship », « tournus » wagons, « local way cars », « transfer cars », etc., and they enable goods to be conveyed direct from the forwarding to the receiving station. When this is impracticable, recourse must be had to one or more transhipments at *tranship centres* which cover a given area.

Should examination of the traffic at a certain station shew that it provides daily a large number of packages for conveyance to stations situated within the zone covered by a tranship station, these packages will be loaded in a « tranship » wagon for despatch to the tranship station mentioned, which in turn will make up reserved wagons for certain stations and will transfer other goods to distributor wagons. Such tranship wagons may be regular or occasional.

Where not merely a single despatching station but all the stations in a section are concerned, collector wagons are used for getting the goods to the tranship station whence they are redespatched.

The methods just examined enable the conveyance of the goods to be achieved with only one transhipment; when these are not practicable, several transhipments must be resorted to. In practice, where important streams of traffic are concerned, an effort is made to limit the number of transhipments to two.

The determination of the tonnage necessary to justify running a reserved wagon depends on several mutually opposing factors, chief of which are :— quick transit and satisfactory loading ratio. The sacrifices which can be made from the latter point of view depend on the general *stock of wagons* available. Various solutions may be adopted according to the flow of traffic. If the employment of a reserved wagon avoids several transhipments, it might be worth while to authorise it for a smaller tonnage than when only a single transhipment would be avoided, and in the direction of the flow of *empty* wagons a lower tonnage could be allowed than in the opposite direction.

As a general rule, the minimum tonnage required for the provision of reserved wagons is between 2 and 3 tons. It may be reduced for light goods on

condition that the wagon is filled to capacity.

According to the different railways, the making up of all wagons of parcels follows a fixed programme drawn up in advance (German Railways, for example) or a combined programme (Italian Railways, for example) one being drawn up in advance for a portion of the wagons only, and the other the optional one, left to the initiative of the local staff in charge, applying to the other wagons.

This difference of system is explained by the nature of the flow of traffic which, in certain countries, is practically permanent and regular, whilst in others it varies in intensity considerably and is of a seasonal character.

In any case it is essential that the loaders should be thoroughly conversant with the order of the stations on the distributing sections and possess simplified written account of the main outlines of the organisation established.

10. — *Mode of conveyance of express parcels.*

As regards the « mode of conveyance of express parcels », we cannot do better than to reproduce the section of Report No. 1 which gives the main outlines of the organisation generally applied on the various railways :

The method followed for the transport of express parcels on a system comprises :

1. The determination of appropriate trains.

2. The scheduling of wagons for regular running in these trains with indications of their function, for example — *reserved* for such and such a station — *collector* for such and such a section having as destination a given station.

To these regular wagons must, of course, be added occasional wagons whose use is *obligatory,* whenever they can produce more rapid handling than the scheduled wagons.

Daily and seasonal fluctuations in express traffic cause the regular wagons to be redundant on occasions or inadequate on others. In such cases their withdrawal or duplication is the remedy. When the scheduled wagons are, from the above cause, withdrawn, it is then necessary to specify in what alternative vehicles the goods must be conveyed. When the scheduled wagons are duplicated, there arises the necessity of taking certain precautions when a number of batches of goods are to be handled; thus, in order to facilitate distribution at stations it is helpful to *appropriate one of the wagons* for certain batches and the other for the remaining batches.

The necessity for performing shunting operations in an expeditious manner at wayside stations, makes it desirable to decide in advance the order in which the various wagons are to be arranged in the trains. It is, moreover, necessary, in certain cases, whether by reason of the nature of the goods under conveyance, or with the object of ensuring still greater simplification of the shunting, to stipulate the particular variety of rolling stock to be employed. It might be required, for instance, that a certain wagon should be fitted with a hand brake on account of the position occupied by it in the train.

All of the preceding requirements form the subject of instructions which are issued to the various stations for their guidance.

11. — *Procedure at departure stations.*

The loading of packages, especially express parcels, is carried out in many stations on the passenger platforms. For this purpose, and in order to expedite the work, the goods are arranged in advance on trolleys which are placed in convenient positions.

In the more important stations, loading generally takes place from platforms in a special shed or depot.

One method consists in sorting all the goods out in the shed according to direction. From all the packages thus assembled are selected those required to make up the largest possible number of *occasional* loads (reserved, distribu-

tor, group or transhipment wagons) procuring a more rapid delivery than by the regular scheduled wagons.

Only packages which could not be loaded in the occasional wagons thus made up are loaded in regular wagons.

The advantages of this method are the satisfactory use of the rolling stock and the reduction of the number of transhipments, but on the other hand it has very serious drawbacks.

It assumes, in effect, that at the end of a sufficiently long period of time, often by the end of the day, there will be assembled in the depot a large number of packages for the same direction, but this condition is usually incompatible with the necessity for the rapid despatch of express parcels and for forwarding them in the same direction by different trains, and it also necessitates special arrangements in the shed for sorting the packages.

Finally, although this method might be considered in the case of very irregular traffic, it can scarcely be justified in general, as a careful study of the traffic usually enables the judicious selection of regular wagons thus making occasional loads infrequent. Further, this method is in fact rarely employed.

A second and opposite method consists in loading the parcels, as they arrive, into the appropriate regular wagons. Direct loading on to the wagon has the advantage of avoiding double handling with resultant expense and possible damage to the packages, and may also enable goods to be despatched more promptly. A difficulty arises, however, in regard to the loading of wagons with mixed lots, in which case, in order to permit of the correct sorting of these lots or batches it is worth while arranging them on the ground before making up the loads. This procedure, moreover, is consistent with the fact that it is not usually possible to place at the platform at one time the full number of regular wagons scheduled. In the reporters' view the best procedure consists in placing at the loading platform, with a view to their direct loading, those wagons to be loaded with only a small number of lots (such as reserved wagons and transhipment wagons) the goods for the other wagons being placed on the ground for the time being.

Whatever method is adopted, it is of primary importance to have a competent staff of loaders. With this object in view it is desirable to have a permanent staff in the shed and to make them well acquainted with the geography of the system and the routine of the shed, so that whatever the destination of a package, the loader will know at once its correct wagon or bay.

Notebooks containing a list of the stations on the system and opposite each the numbers of the wagons serving them or the bay allocated in the shed, would be a helpful guide in the education of the staff.

When « express » parcels are loaded on to trains during wayside stops it is necessary on the majority of systems, owing to the short time available, to hand simultaneously to the train staff both the packages and the documents. Mutual checking with signature of the two parties is hardly ever required now except for certain value parcels.

12. — *Transmission of documents.*

The documents may be forwarded by the quickest means, independently of the goods to which they refer. The parcels handling is then dealt with solely in accordance with the indications on the labels.

This method is applied on certain systems but it often happens that, in practice, the quickest means of transmission is by the actual train conveying the goods. Moreover, on distributing trains, the presence of the documents is particularly useful in assisting the train

staff in getting the goods ready for unloading at successive stations. Hence, the majority of Administrations require that the documents shall accompany the packages.

In the case of a reserved wagon between two stations only, the consignment notes and documents appended thereto are frequently placed in the sealed wagon to prevent them going astray.

In respect of other wagons, the head guard takes charge of the papers relating to the collector or distributor wagons on his train, sorts the documents corresponding to goods collected, and for the distributing section of the journey gets the papers for the various stations ready for handing over with the parcels.

13. — *Duties « en route ». Train staff.*

For the satisfactory execution of the work en route (seeing that goods are loaded into the appropriate wagons by the stations, judicious division of staff between the distributor wagons, preparation of packages with a view to their rapid unloading at wayside stations, etc.), it is essential that reliable and energetic men should be employed.

On lines where the traffic is heavy, specially-trained men are employed by certain Administrations. On the Netherlands Railways, for instance, the staff have to pass an examination on the geography of the line, the system of express goods forwarding, the stowage of packages, etc., and a special bonus is awarded to those who do well in this examination.

In order to facilitate the work of the train staff on important lines and to reduce standing time at stations, various systems have been devised, such as wagons fitted with communicating gangways and the device used on the French Est Railway for the rapid unloading of fish, etc. In addition may be cited the employment of bags, baskets and crates for the handling of small parcels and for loading fragile or valuable articles.

The use of these latter loading accessories is not very widespread, however, owing to the difficulty of returning the containers to the despatching centres when empty.

14. — *Transhipment stations.*

It is only proposed to deal here with transhipment at important centres normally receiving a large number of wagons loaded with parcels the transhipment of which is systematically organised. These centres are generally provided with special equipment.

As in the case of the operations at departure, two distinct methods may be considered. The first would consist in unloading all the parcels in the depot in order to group them subsequently by making up the greatest number of occasional wagons. For reasons already explained in connection with the operations on departure, this method is very seldom applied. The short period which generally exists between the arrival of a package and its departure by a specified train constitutes, moreover, a serious obstacle in « fast » traffic.

The method generally applied consists in endeavouring to obtain *wagon to wagon transhipment* as far as possible.

All the wagons of parcels traffic arriving at a transhipment station are passed into the shed in accordance with standing instructions which take account of the sequence of the trains both on arrival and departure.

The packages are unloaded and transferred at once to the wagon which is to convey them farther whenever such wagon is at the loading platform.

Wagons having the station as terminating point are generally made use of after *partial unloading*. The satisfactory re-use of the wagons is obtained thanks to the experience of the loaders special-

ised in this work, who very rapidly become acquainted with the flow of traffic and the approximate quantity of the lots carried by the various wagons. Examination of the documents, where these accompany the packages, assist them to adopt the best procedure.

By this method the unloading of goods on to the platform is reduced to a minimum, especially if care is taken to maintain a regular and well-timed service into and out of the transhipment shed. In order to minimise trucking of the goods it is desirable to have fairly narrow platforms. On the other hand, the length of the platforms should be based upon the number of wagons which are required to be loaded or unloaded simultaneously.

It may happen that two trains between which parcels have to be transferred are in a station at the same time, in which case it is desirable to have two tracks available on either side of a loading platform. The transfer having been effected, both trains are ready to depart after having made a relatively short stop.

Reference may be made in this connection to the typical case cited in Report No. 1 : the station of Rognac (Paris-Lyons-Mediterranean). This station possesses a transhipment platform 250 m. (820 feet) in length and 7 m. (23 feet) wide, flanked by two tracks having direct access to the main line by facing points. The timetables of the freight trains are drawn up in such a manner as to limit the maximum stay for the transhipment of parcels to 4 hours.

The activities of a transhipment shed for fast traffic, being dependent on the times of arrival and departure of the connecting trains, vary considerably in intensity during the course of the day, and the number of the staff therefore varies accordingly. Each gang consists of a foreman and a number of porters. Transhipment is effected by reference to the labels by the foreman, who instructs the porters as to the wagon in which each package should be loaded or as to the bay of the shed at which it should be placed.

With regard to reloading of packages temporarily off-loaded, it is desirable, especially if the goods are for mixed loading, to carry out a preliminary sorting and classification of the goods as they are brought up by the barrow men. In the particular case of a wagon having to leave the depot after a very short stop in order to distribute goods on a nearby section of line, it may be of advantage to have this sorting done by the staff of the train in which the packages will be conveyed, as their subsequent work en route will thereby be facilitated.

As a general rule the work of transhipment is carried out by the station staff, but on certain systems (e. g., the North of Spain Railways) the permanent members of the gangs are reduced to a few station men responsible for directing the work, the actual handling being done by the train staff accompanying the wagons.

Trucking can be carried out by men having no special skill, such as temporary hands or labour furnished by a contractor, but on the other hand too much care cannot be devoted to the selection and training of the men who examine the goods and direct the work of transhipment.

CHAPTER III.

Organisation of ordinary parcels traffic.

CONTENTS.

a) General organisation.
b) Operations at departure stations.
c) Working of the transhipment centres.
d) Operations at arrival stations.

a) General organisation.

1. — *Regular wagons.*

On all systems, with very few exceptions, there is an organisation of *regular*

wagons for parcels running daily *without tonnage restrictions* over fixed routes, the wagons being so scheduled that any station may send a consignment of parcels daily to any other station on the system (or to any junction with adjacent systems), arrangements being made for connections at stations not served directly by trains from the originating station.

These regular wagons have a clearly-defined purpose which is practically always the same and which has already been explained in this report in connection with the consideration of fast goods, viz., *collectors, distributors, collector-distributors, reserved* and *transhipment wagons.*

The aim of all Administrations is to establish an organisation ensuring the rapid conveyance of parcels, for which purpose account has to be taken of varying and sometimes contradictory factors such as the number of transhipments, the number of vehicles to be earmarked for such traffic, and the economical use of rolling stock, etc., and preponderance bas been given to one or other of these factors according to the circumstances and the point of view of the Administrations concerned.

Mr. Mermont, in the section of Report No. 1 dealing wit « slow parcels traffic » of which he has made a special study, has analysed in a very detailed manner the four fundamental methods (A, B, C and D) on which the various methods of organisation of the transport of parcels by goods train are more or less based, and has brought out very clearly the results of the method chosen.

We will confine ourselves to recalling them briefly, assuming a System to be divided into « N » sections.

Method A. — Transport of parcels from any station to any station *without transhipment.*

Method A necessitates the use of N-1 collector-distributors for each despatching section, i. e., for the whole System: N (N-1) wagons.

The two stopping trains (one in each direction) of each section have to take a minimum number of 2 (N-1) regular small-consignment wagons.

Method B. — Transport of parcels from any station to any station *with not more than one transhipment.*

Supposing that the system has p tranship centres (C1, C2..... Cp), each being responsible for a certain distribution zone.

Under the method B, each station is served by p collectors terminating respectively at C1, C2..... Cp, and should a consignment require to be forwarded to station B in, say, the zone covered by centre C4, it will be loaded in a collector having C4 as its terminal point, and after transhipment will continue its journey in a distributor wagon serving station B.

Method B requires the daily use of Np collectors + N distributors, i. e., N (p + 1) regular wagons.

The two stopping trains of each section have to take between them a minimum number of p + 1 regular wagons.

Method C. — This method, which is only a variation of the preceding one, also provides for the transport of parcels from any point to any point with *only a single transhipment at most.*

It differs from method B as follows : the p tranship centres are each responsible for a collecting zone instead of a distribution zone. Each station is served by a single collector terminating at the centre to which it belongs. This centre then arranges for N distributors to serve each of the sections on the system.

Method C requires the use of the same number of wagons as method B.

Method D. — Transport of parcels

from any station to any station *with only two transhipments at most.*

The principle of method D is as follows : the consignment is despatched to a transhipment collecting centre situated near the forwarding station. This centre, after transhipment, reforwards the consignment in a transhipment wagon direct to a transhipment distribution centre situated near the destination station. This latter centre, after transhipment, sends the consignment on to the final destination in a distributor wagon. Each centre acts both as a « collecting » and as a « distributing » centre for the stations in its zone.

Method D requires the daily use of a minimum number of 2 N collectors + p (p-1) through transhipment wagon + 2 N distributors, i. e., a total of : 4 N + p (p-1) regular wagons.

The two stopping trains of each section have to take a minimum number of 4 regular wagons.

Mr. MERMONT has applied the formulae characterising the A, B, C and D methods defined above to two concrete cases :

A small system R^1, comprising 20 sections and 2 transhipment centres;

A larger system R^2, consisting, like the Franch Est Railway, of about 5 000 km. (3 000 miles) of line and comprising 190 sections and 16 transhipment centres, and has made extremely interesting deductions therefrom leading up to the following conclusions:

Method A (no transhipment) necessitates a very considerable stock of wagons even for a small system such as R^1, and the shunting and haulage costs are prohibitive.

Methods B and C (1 transhipment), may be considered for small systems not larger than R^1, but are entirely out of the question on more extensive systems. (On a system as large as R^2 the B or C methods would necessitate a stock of about 10 000 wagons merely for conveying parcels and the shunting and haulage expenses would be exhorbitant).

It may therefore be concluded, as Mr. MERMONT does, that for systems of a certain size, the D method, which requires a maximum of 2 transhipments for each consignment (often only 1 and in some cases none at all) can be recommended as offering on the whole the best solution of the problem of consignments of parcels, adequate account being taken of the essential factors : handling, rational use of rolling stock and shunting and haulage costs.

This is confirmed by Mr. FETTARAPPA'S report, in which it is stated that although on very restricted systems such as those of Greece [Piræus - Athens - Pelopponnesus] and of Turkey (Smyrna-Cassaba) there is no necessity for a special organisation for the transport of parcels ; on large systems such as the Czechoslovakian State Railways and Italian State Railways, to mention only two, an organisation based on the principles just considered is indispensable.

Generally speaking, the arrangement comprising the maximum of 2 transhipments is adopted (Method D), but it may be noted, however, as Mr. FETTARAPPA points out, that on the German Railways [a system which extends for about 800 km. (500 miles) from north to south and from east to west] goods forwarded to the most distant destinations (up to 1 000 km. = 620 miles) are not transhipped more than three times.

On the German system there are 116 transhipment stations of which only 40 serve as transit and connecting centres, each station being connected with 4 to 6 transhipment centres and the proper centre for any particular traffic being laid down. The transhipment points may be : *concentration centres, transit and connecting centres,* or *distributing centres.* A consignment for a distant destination may thus be transhipped three times, at the concentration centre, at the transit and con-

necting centre and finally at the distributing centre.

Whatever the system in force, it can seldom be strictly applied in practice, but has to be adapted to traffic requirements. Fairly regular streams of traffic, for instance, require enough *regular* wagons to be put on to ensure rapid despatch with a minimum number of transhipments.

In order to ascertain where these streams of traffic occur it is desirable to make local analyses of the small traffic of the various lines of the system, and these analyses should be made periodically in order to discover any modifications which may have arisen and make the necessary alterations in the scheduling of the *regular* wagons.

2. — *Conditional wagons.*

The carriage of parcels by *regular* wagons is not always the quickest form of transport, particularly when it necessitates one or more transhipments. Hence the stations usually have authority, under certain conditions, to put on wagons entitled « supplementary » or « conditional ». Among these we will only refer here to the « transhipment conditional » the « transhipment conditional for transit to another railway system » and the « reserved conditional ».

All these wagons are conveyed by the most direct trains as wagon-load traffic, their use obviating one or more transhipments. The loading into « conditional » wagons therefore very appreciably expedites the carriage of small consignments, reduces the cost (shunting, handling, etc.) inherent to transhipment and diminishes the risk of damage.

The tonnage required to justify putting on a *conditional* wagon varies considerably according to the country or even the railway system. Certain Administrations prescribe 3 tons and even 4 tons whilst others reduce the minimum to 2 tons and sometimes even to 1 $\frac{1}{2}$ tons. As a general rule it is rare that a single station can in one day get together 3 to 4 tons of traffic for a single destination or even for a transhipment centre, and it would therefore appear desirable to reduce the requisite weight to 2 tons. Care must be taken, however, that stations do not make the mistake of holding back goods in order to get the minimum required for making up a *conditional* wagon, and very definite regulations should be made in this respect.

3. — *Trains used for ordinary parcels traffic.*

Ordinary parcels are conveyed partly by stopping trains serving the sections, and partly by through trains which on the main lines very rapidly convey long-distance through wagons of parcels to destination.

The most usual arrangement for serving a section is for a single stopping train in each direction to run daily, conveying both the parcel and the wagon-load traffic and at the same time carrying out any shunting at the small wayside stations.

This train, which leaves the departure point of the section very early and arrives fairly late at the terminal point, perhaps constitutes an economic solution on lines where there is very little traffic, but the system has a very serious drawback owing to the fact that senders hand in the greater part of their consignments almost at the end of the day, i. e., between 3 and 6 p. m., with the unfortunate result that at a large number of wayside stations an initial delay of 24 hours is entailed.

A much better arrangement is to provide on each line, in each direction in addition to a slow train for the wagon-load traffic a faster train for parcels. The latter train will call at stations after the closing time for receiving traffic (5 or 6 o'clock) and collect the

consignments, which will reach the nearest centre in the evening, be transhipped during the night and continue their journey early the next morning. Such system would of course occasion some additional expense, but this would be justified by the considerable improvement made in the conveyance of the parcels.

Attention may be directed, in this connection, to the system instituted and developed during recent years by the German State Railways, viz., the system of light goods trains known as « Leichte Stückgüterzüge », abbreviated to « Leig ». These trains, which comply with the considerations explained above, can reach a fairly high speed [65 to 75 km. (40 to 47 miles) per hour] and run directly and rapidly right on to the lines adjacent to the goods sheds.

Mr. FETTARAPPA, has given a detailed description, in his report, of the composition of various types of « Leig » trains, together with a number of photographs.

Among the most recent, we may take the type consisting of a single motor coach (Maybach-Diesel motor of 150 H. P.), with four speeds, the highest of which is 65 km. (40 miles) per hour, having a capacity of 76 m^3 (2 684 cubic feet) and loading 15 tons. The interior of the train is artificially lighted and heated, and has a W. C., a small table and pigeon-holes for documents. The handling operations are facilitated by the intensive use at yards and stations of hand conveyor-trucks, trays used as containers, loading gangways, etc., so that the effective speed can be maintained at a high level.

The German Railways run the « Leig » trains over almost all parts of the system, 260 being in service at the end of August, 1931.

Mr. FETTARAPPA reports that the Italian Railways also have introduced special fast light trains termed « treni rapidi collettame » for the conveyance of parcels on a few lines where traffic is heavy and more than usually threatened by road competition. En route, the train staff prepares the packages for unloading and, by the use of communicating gangways between the vehicles, effect the necessary transhipments from one wagon to another.

The majority of the other Administrations consulted have not yet experimented with the system of « Leig » or similar fast light trains, although some of them (French Est, Norwegian State, Netherlands) are considering the matter.

The Swiss Federal Railways state that as a result of the enquiries made by them into the question they have concluded that the system would not be suitable in their case.

In the opinion of the reporter it is premature to make a final decision on this question, seeing that although the introduction of such trains on certain systems is only in its experimental stage they appear to have achieved a considerable step forward so far as the speeding up of small consignments traffic is concerned.

On main lines where a large number of trains are scheduled, it would seem, a priori, easier, having regard to the number of small-consignment wagons to be conveyed, to run them in a special train and exclude wagon-load traffic therefrom. Such, however, is not the practice adopted by the great majority of Administrations, owing to the fact that it is often desirable for stations lying along a main line to avail themselves of the numerous passing trains in order to despatch whatever goods are on hand at frequent intervals during the day.

Marshalling of parcels wagons in the trains.

In the stopping trains, most companies keep the wagons of parcels together, either at the front or at the rear, in order, it is stated, to facilitate shunt-

ing and handling the parcels at intermediate stations by making these operations independent of each other.

On through trains, certain systems make no distinction but mix the wagons of parcels in with the wagon-load traffic, whilst others arrange them either in front or in the rear portions of the trains.

In the reporters' view, the practice of keeping them together is desirable both in stopping trains and in through trains, as the gravity shunting of these wagons at sidings can be avoided by taking them off immediately on arrival of the train, and running them either to the marshalling yard and placing them in the front of the connecting train, or, where the loads have to be manipulated, to the transhipment shed. This procedure has the double advantage of reducing the risk of damage and accelerating the forwarding of the wagons.

Mr. MERMONT has pointed out an interesting measure applied by the Dutch Railways whereby wagons of parcels are given *priority* over all other wagons except, of course, those loaded with live stock or perishable goods.

* * *

The problem of the general organisation to be adopted for the transport of parcels cannot be solved in a uniform way.

As stated at the beginning of this chapter, various factors are involved such as rapidity of conveyance, handling, use of stock and haulage and shunting costs. Each factor must be examined very carefully and, in each individual country, the *principle* of the organisation will probably require to be modified with the passage of time and to meet contingencies such as scarcity of labour, lack of rolling stock, unusually high fuel costs, etc.

It seems essential, however, not to lose sight of the principal factor of the problem which, at the present time, is undeniably *rapidity of conveyance*. As the Finnish Railways very rightly state in their reply, « Before the advent of road competition, the utilisation of rolling stock was the dominant factor in this organisation; today it is the speed of conveyance ». This is exactly our own opinion ; the whole aspect of the problem has changed.

* * *

b) **Operations at departure stations.**

It is not proposed to deal here in detail with the operations at departure stations, explained by Messrs. FETTARAPPA, MINSART and MERMONT in their respective reports, but merely to indicate which of the various practices adopted appear to be the most carefully worked out and therefore the most recommendable.

1. — *Period for despatching goods.*

As a general principle each consignment handed in should be despatched *by the next following « regular » wagon* available connecting with its destination unless room is found for it in a *conditional* wagon.

Nearly all the Administrations are agreed on this point, but differences of opinion occur in the case of stations being given latitude to defer despatch, on occasion, with a view to the accumulation of goods received over several days being sufficient to justify making up *conditional* wagons.

It is the reporter's view that, while it may be deemed expedient in certain cases to deviate from the principle of immediate despatch, such deviation should only be allowed within well-defined limits at particular stations, and subject to vigilant supervision being exercised.

Further, if the *occasional* wagon which it is hoped to make up cannot, *for any reason whatever*, be *loaded* and *despatched* at the latest by the evening

of the day following that on which the consignments were handed in, there should be no hesitation in giving orders for the goods to be loaded on that following day in the appropriate *regular* wagon.

2. — *Programme for the handling of goods.*

In order to ensure speedy conveyance of small consignments, it is very necessary that the period for despatch should be as short as possible (subject to what has just been stated with regard to making up *conditional* wagons) and, in addition, that the packages should be loaded in the *right wagon* i. e. in the most appropriate wagon for conveying them to their destination.

The determining of this wagon means nothing more or less than the compilation of a loading programme for each handing-in period, and in the reporter's opinion the establishment of this programme should not be left to the handling staff but regularly entrusted to a qualified man (indoor rather than outdoor), thoroughly conversant with the instructions regarding small consignments and with the geography of his own and adjacent systems.

Mr. Mermont has given full details of a method which might be adopted with advantage. It consists mainly in applying to the invoices — which represent the packages — the rules applicable to the loading of the goods themselves; thereby working out, by proxy as it were, an advance scheme of allocation of the goods to the various regular or conditional wagons, finally handing the invoices thus classified to the loading staff, which has only to observe *strictly* the arrangement laid down.

3. — *Loading of the consignments.*

Generally speaking, loading cannot be commenced until the invoices have been sorted, and this cannot be completed until after the handing-in period for each *regular* wagon. Premature loading may give rise to inaccuracies and thus delay the despatch of the consignments.

This rule is not absolute however. There is no serious reason, for instance, why the loading of a *reserved regular* wagon should not be commenced at any time during its *handing-in* period, and similarly, in the case of a *reserved conditional* wagon, as soon as the possibility of obtaining sufficient tonnage becomes apparent. By deviating from the general rule in these particular cases the handling and despatch of the packages can be advanced, and the shed kept clear, thus reducing the actual accommodation required.

c) Working of the transhipment centres.

1. — *Definition of transhipment centres.*

By « transhipment centres » are meant those important points towards which regularly converge large numbers of wagons of parcels the contents of which are systematically transferred into other wagons.

The number and distribution of transhipment centres, varies from one railway to another according to the size of the system, the layout of its lines, the density and flow of its traffic and also according to the type of organisation adopted by it for the transport of small consignments.

In spite of the natural desire to do so, it is better not to reduce too greatly the number of transhipment centres, as otherwise very undesirable cases will arise where goods have to travel considerably farther than the direct distance owing to the necessity of passing through an outlying transhipment point. In short, the advantage to be gained by reducing the number of transhipment centres is counterbalanced by the risk of lengthening the time that certain goods are in transit. In each case therefore the optimum arrangement has to be determined.

2. — *Hours and days of work at transhipment centres.*

On nearly every system the transhipment sheds function during the day, the period extending, as required, from the early hours of the morning until last thing at night. Only in special cases is transhipment work regularly done at night.

As regards Sundays and public holidays, the replies indicate that the sheds are closed in Sweden, Norway, Switzerland and Holland, and on the French Nord system, and open in Italy, Bulgaria, Germany, etc., permanently or seasonally.

In view of the increasing road competition it seems that all the systems will have to keep their transhipment depots open on Sundays and public holidays, as, from the point of view of delay, the same considerations do not apply as in the case of local stations where no goods are received on such days.

3. — *Lay-out.*

Ordinary parcels traffic on large railway systems calls for specially-devised transhipment accommodation with a view to rapid manipulation of the parcels and a proper loading of wagons.

At stations with only a moderate amount of local and transit traffic the transhipment accommodation may with advantage be combined with the local sheds, several examples of this practice being given in Mr. FETTARAPPA's report.

The transhipment lay-outs vary greatly in design according to the different countries and even railways, as they are often the result of progressive development of a particular arrangement which perhaps originally was not based on any definite or systematic transhipment practice.

The *elementary* lay-out consists essentially of a loading platform with a line on either side. In the more modern transhipment depots a row of several such platforms is provided, the two centre ones having, on occasion, only one track between them, called the centre bay. In some sheds the bays are arranged in the form of steps, this having the merit of enabling certain wagons to be placed in position or withdrawn without interfering with others. On the other hand, it requires more frequent and consequently more costly shunting.

The report of Mr. FETTARAPPA gives the characteristics of some of the more modern lay-outs such as :

— Cologne Kalk Nord,
— Wahren,
— Milan (shunting yard).

With regard to the lighting of transhipment sheds, this is nearly always provided in modern installations by fixed electric lamps conveniently distributed along the platforms, and portable electric lamps for lighting the interior of the wagons. The plug-in points are often placed on the pillars of the transhipment platforms (e. g. on the Italian State Railways), while certain systems (e. g., the German State Railways), prefer the system of a double copper wire line extending the whole length of the transhipment platform and on which is suspended a running connection carrying the lamp extension.

4. — *Methods of transhipment.*

Transhipment is performed in different ways according to the Administrations.

On some systems all that is done is to « retouch » the incoming wagons, which simply consists in removing from one wagon and depositing on to the platform those parcels which do not have to go in the same direction as the remainder, and to add thereto goods which are going in that direction, taken from wagons in the shed at the same time or unloaded previously. This method of procedure obviously reduces transhipment to the absolute minimum,

but is not very methodical and is not conducive to the goods being loaded to the best advantage or the formation of *conditional* and *through* wagons which speed up the transit so much.

Another method is for all parcels to be unloaded from the wagon on to the platform, and then to be sorted in the same way as at a local station. This system gives the best possible loading arrangement but has the drawback of necessitating very wide platforms and entailing double handling, which is both lengthy and expensive.

A third system, known as « direct transhipment », entails transhipping the goods direct from the wagons which arrive to the empty wagons standing ready, the latter being made up partly into the *regular* wagons scheduled for despatch from the transhipment centre in question and partly into *conditional* wagons. In practice, however, goods intended for a *distributor wagon* have to be placed on the platform owing to the necessity of sorting them in the geographical order of the stations, which fact also makes it impracticable for the parcels to be placed in their wagon until the complete load is assembled ready nearby.

This method almost entirely eliminates dumping on to, and picking-up from, the platform, and thereby reduces the handling work very materially, but it cannot be said to make possible such a good loading result as the preceding method.

With the method of « direct transhipment » loading must commence at the same time as the transhipment operations, so that at no one moment are the *whole* of the goods in hand having regard to the successive arrival of wagons, and the result may be that opportunities are missed of making up a certain number of *conditional* wagons, which would not be the case if the method of unloading all the parcels on to the platform were adopted.

Nevertheless, the advantages such as economy of labour, saving of time, reduced width of platforms, etc., which are gained by the method of « direct transhipment » appear to outweigh the disadvantages, and there is a growing tendency at important centres provided with modern installations to introduce it.

d) Operations at arrival stations.

The part played by arrival stations in the matter of parcels consignments is relatively passive. It is felt, however, that attention should be drawn to a practice tolerated by certain administrations whereby stations are allowed, in certain cases such as when a train is running late, to detach *regular* wagons whose terminal point is situated farther on. The reporter's view is that it would be better to prohibit this practice, as it has the effect, for the sake of a minor convenience reaped by one station, of delaying all the other parcels contained in the wagon, and this delay becomes absolutely inadmissible if several stations along the route act successively in the same way. It is considered preferable to delay a stopping train rather than hold back an entire wagon-load of parcels.

CHAPTER IV.

Handling appliances used in the conveyance of parcels.

The use of appropriate mechanical or electrical appliances for loading and handling operations has the threefold object of reducing delay, avoiding damage and lowering costs.

The principal types of appliances used in the loading, unloading and transport of parcels on passenger platforms or at station depots are briefly summarised as under, viz:

— hand barrows, trolleys and trucks;

— two or four-wheeled trucks, plain or with an elevator (conveyor) plat-

form, recent models being fitted with automatic braking.

— trains of trolleys with electric or motor tractors and consisting of trailers variously constructed according to the types of goods. These trailers are often fitted with ball bearings and rubber types to give easy running and prevent noise.

— hand or electrical pulley tackle for facilitating the handling of heavy packages, permitting horizontal movement of some extent through the pulley being carried on a trolley running on an overhead rail or system of rails connected by switch points or turntables.

— small hand or mobile cranes particularly suited to the movement of heavy loads about the shed.

— various types of appliances commonly known as « stackers » for stacking packages.

— electric lifts for movement from one level to another, particularly when the reception and loading of goods takes place on various storeys in the depot.

— chutes, which are more economical than lifts and far quicker, but only suitable for non-fragile goods and packages of suitable shape.

— roller transporters, and belt conveyors, for obtaining horizontal movement, but their adoption is restricted by their high cost.

— etc...

It is not proposed to go into any details of the numerous types of appliances, the characteristics of which differ according to their construction and the use for which they are intended.

The type of equipment which would be too costly for a small centre might be very suitable for a busy station where large quantities of packages are handled and moved about daily. Each case must be dealt with on its merits.

In addition to the appliances briefly indicated above, attention may be drawn to a few ingenious devices mentioned in the reports of Mr. Mermont and Mr. Fettarappa, viz:

— the light crane, fitting on to the door pillar of certain wagons on the French Est Railway, which can easily be transferred from one door to another and enables cage trucks or hampers of packages to be loaded or unloaded at transit stations. Details of this appliance are given in Mr. Mermont's report which also indicates the very favourable results obtained with them on the French Est Railway, especially in the handling of small boxes of fish. As a rule, the time taken to unload a truck loaded with 400 kgr. (880 lb.) of fish is less than one minute.

— the special transporter wagon described by Mr. Fettarappa, which at centres on the Italian State Railways where an average amount of transhipment takes place, runs on a track situated between the two tracks on which are placed the wagons containing the parcels to be transhipped from one wagon to another. The floor of the transporter wagon is the same height as that of the loaded wagons and has a surface of 32 m² (344 sq. feet). It is lighted by electricity, with plug-in points for lighting the interior of the wagons and has a roof and two end-pieces.

The use of this transporter wagon avoids the necessity for a fixed transporter installation, whilst enabling the same amount of work to be effected.

CHAPTER V.

Résumé and Summaries.

a) *Résumé.*

— The conveyance of parcels represents a relatively small amount of traffic as compared with consignments in full wagon loads, but the receipts derived therefrom by the railways are never-

theless valuable owing to the high rates generally charged. On the other hand, the net cost per ton of conveying such traffic is much higher than that of full wagon loads.

— Whatever system is in force it is desirable for the railway to keep within whatever delivery periods it has been able to fix, if it wishes to defend its traffic against road competition.

— Parcels are generally accepted every day (except Sundays and public holidays for ordinary goods train services) and for any destination.

— One method of fighting road competition consists in granting reduced rates to agents grouping parcels into single consignments between particular points where active competition is felt, the lower rates being justified by the very appreciable economies realised, the railway only having to deal with a single sender by whom the traffic is handled.

— The labelling of packages entirely by the sender saves time and labour, but it is more reliable when done by the railway and more likely to ensure that consignments are forwarded properly.

— The necessity for reliable labelling is particularly felt in the fast services, owing to the limited time available for handling.

— In order to simplify and speed up the operations of weighing and charging of parcels at busy stations, it may be useful to employ a number of weighing machines, preferably automatic, situated at the most suitable points in the receiving shed. It may also be of advantage to adopt the mechanical system of charging in force at a few of the large stations on the German Railways.

— Special labels placed on wagons conveying parcels contribute to accuracy and rapidity in loading, unloading and shunting operations.

As a general rule, the conveyance of parcels by ordinary goods train is organised on similar lines by the various Administrations, the essential principles being as follow :

Every station ought to take steps to compile *a daily parcels loading programme* comprising the making up, in accordance with the rules already explained, of *conditional* through wagons so as to obtain quick and reliable transit of the traffic in question;

Consignments not fulfilling the requisite conditions for inclusion in such *conditional* wagons must be dealt with in accordance with a *general forwarding plan,* so arranged in regard to the number and allotment of *regular* wagons that each station shall have available a *regular* wagon by which to forward a consignment whatever its destination.

— At the present time, and having regard to the competition which the great and rapid progress made in motor vehicle technique has rendered particularly effective in the last few years, the railways ought not to hesitate in order to retain their traffic to improve their equipment and to give greater elasticity to their rates.

— The principle of the « best possible user of stock » ought to give way to the imperious necessity of achieving rapid transit from the forwarding to the receiving station and, if possible, from door to door.

— No rigid form of organisation ought to be considered as able to provide by itself a satisfactory solution of the problem of quick transit by rail.

— Whatever system is used ought to be elastic and adapted to the varying requirements of traffic, hence the necessity for periodical traffic analyses.

— As soon as the existence of a definite movement of traffic is noticed, particularly if the flow is a regular one, there ought to be no hesitation in providing one or more *regular* and *through* wagons, even if the loading

ratio leaves something to be desired to commence with.

— Sudden but appreciable spurts of traffic should also be catered for by boldly reducing the usual tonnage required for putting on a *full conditional* or a *grouped consignments wagon.* (It may be objected that in thus augmenting the number of through wagons an increase in shunting and haulage costs will be caused, but primary considerations must come before secondary ones).

— As regards train services, it seems essential to separate the ordinary parcels service from the wagon-load service.

— It appears most desirable that the fast trains should be used to collect the parcels at the end of the day, and that they should leave the parcels for these stations each morning. The organisation on this method by the German State Railways of the « Leig » light goods trains merits the closest attention.

In addition to the general organisation itself, emphasis has been given in this report to certain rules and methods of procedure which are calculated to enable the railway to improve the conveyance of ordinary parcels. These are repeated concisely hereunder :

— Insist upon the stations sending the parcels away quickly and loading them correctly;

— For despatch, lay down the simple rule « despatch without fail by the first following *regular* wagon calling, travelling to the destination of the consignment; or if required, put on a *conditional* wagon for despatch not later than the day after the goods are received ».

— To obtain « correct » loading require the compilation of the *loading programme* referred to above, preferably by a qualified man.

— Make the necessary sacrifices for speeding up handling operations at the forwarding and receiving stations and transhipping centres by the use of the most appropriate mechanical appliances such as tractors, trucks, elevators, containers (boxes, trays, cage trucks), etc.

— The practice of specially marshalling wagons of parcels in a certain order in the trains might be generally adopted with beneficial results, as it has the double advantage of speeding up the turn-round of such wagons, and reducing the risk of damage, as the necessity for gravity shunting is avoided.

— In marshalling them in the trains, wagons of parcels should be given priority over all wagons other than wagons of live stock or perishables.

— The application of direct transhipment at transhipping points whose appliances lend themselves to this method appears to be advisable.

— Vigilant supervision is essential for obtaining the strict observance of the regulations governing ordinary parcels traffic. The best course is to check the actual way the consignments were dealt with either on the occasion of delay or claims arising, or by surprise checks.

Examination of the documents and the stamp impressions which stations of call should be required to make thereon clearly reveals irregularities or omissions in the organisation. The former can be corrected, and the others remedied easily.

— Above all, steps should be taken to educate the employees to appreciate the desirability of the measures prescribed, even to stimulate a competitive spirit, and to convince them of the necessity of faithfully carrying out the instructions devised to ensure rapid and regular conveyance of small consignments by goods train.

b) *Summaries.*

The organisation for the conveyance of parcels consists of two main parts, viz., conveyance by *rail* and the auxilia-

ry conveyance from the sender's premises to forwarding station and from receiving station to the consignee's premises.

As regards conveyance by rail an endeavour has been made in this report to bring out what has already been done by the railways to improve the transport of parcels and an indication has been given, in the résumé, of the agreed conclusions drawn from our own investigations and those of our colleagues.

One point, however, deserves emphasis, viz., the desirability of substituting for the multitude of forwarding and receiving stations a limited number of well-chosen centre stations each for a zone of about 30 to 40 kilometres radius (20 to 25 miles) which would constitute the actual *rail* forwarding and receiving points for parcels.

By thus concentrating all the parcels of a zone at the centre forwarding point, the railway would more easily realise all the conditions necessary for loading numerous full wagons or grouped consignment wagons for direct and rapid transit to the receiving centre station of the destination zone.

Moreover, it should not be overlooked that the superiority of the road motor is due above all to the *convenience* afforded to the trader by removing the necessity of arranging for the cartage of his traffic at the forwarding and receiving ends.

The efforts of the railway ought therefore to be in the direction of so organising its services as to make it advantageous for a road motor accepting goods from sender's premises for a distant destination more than, say, 50 to 60 km. (30 to 40 miles) away, to use the railway for the main part of the journey.

To obtain this result, i. e., to bring to the rail all medium and long-distance traffic, it is essential for the railway to resolve the two questions of *rates* and *time*.

As regards rates, a simple basis derived from road motor practice (wagons hired to agents grouping consignments, and charged for empty or loaded haulage at a flat rate per kilometre or mile) appears to be particularly worthy of recommendation. It would likely induce these agents to discard road-motor conveyance in favour of placing the traffic on rail at the forwarding zone centre station for conveyance to the destination zone centre station, labelled to an agent responsible for distributing the parcels to the consignees, and would also give them an incentive to find a return load.

A system of charges of this kind has recently been proposed in France by the main line railways. The fixing of the basic charge in this system is of course governed by the net cost by the road motor and consequently may vary from country to country. (The rate contemplated by the French railways for a 10-t. (9.8 Engl. ton) wagon is 3 francs per km. (5 fr. per mile).

With respect to *time*, the total duration of combined transit (road - rail - road) must not exceed the time taken for throughout conveyance by road. With this object in view the railway should:

a) carefully co-ordinate at each centre station the arrival of the collecting lorries and the departure of the parcels wagons, and, vice versa, the arrival of the parcels and the departure of the delivery lorries.

In practice, as collection will be effected towards the end of the afternoon, the departure of the wagons should take place in the evening, so as to get the advantage of the night period immediately following acceptance of the goods.

At the destination points, the wagons should arrive early enough to enable the delivery lorries to leave first thing in the morning.

b) speed-up as much as possible, by

specialisation, the trains conveying wagons of parcels. Each line should be served daily by two trains, a distributing train in the morning and a collecting train in the afternoon. These trains should be lightly loaded, and would only stop at the centre stations.

The risk, on railways where the ordinary and fast services co-exist, is that traffic will pass to the former from the latter, but there is no doubt whatever that this is far preferable to losing the traffic altogether.

A last point requires to be dealt with. It has already been indicated how, with reduced (wagon-kilometre or wagon-mile) rates, groupage agents may be induced to make up full wagons for conveyance between districts having a large regular and balanced flow of traffic between them. But how are these agents to be persuaded to bring to the centre stations the small separate parcels consignments which cannot be loaded in a full-load wagon ? In our opinion, one solution which may be considered — except of course in places where the railway itself collects and delivers — is to give agents a bonus on all consignments brought to a centre station for conveyance by rail at the high standard rates applicable to small parcels.

Finally, to repeat the final conclusions of our Report No. 1, it would appear that if the railways wish to prevent their parcels traffic from disappearing and to recover the traffic already lost, they must so organise it that it can be conveyed from door to door very quickly and at suitably adjusted rates, by road-rail services in connection with a system of centre stations as described above, designed to encourage the groupage of parcels traffic. According to circumstances, the railway may either effect the whole of the combined carriage itself, or leave to private undertakings in competition with each other, or to a particular agent, the collection and delivery of the parcels traffic by road motor in the districts served by the centre stations.

[656. 254]

QUESTION IX:

Automatic train control and train stop. Track equipment. Locomotive fittings. Methods used for repeating signals on the locomotives. Devices intended to ensure the attention of the drivers,

by W. STÄCKEL,

Special Reporter.

Question IX was made the subject of these reports drawn up by Messrs.:

— G. H. Crook — (America, Great Britain, its Dominions and Colonies, China and Japan) (1);

— V. Vlaikoff — (Belgium, Spain, France, Italy, Netherlands, Portugal and their Colonies, Denmark, Finland, Luxemburg, Norway, Sweden and Switzerland) (2);

— W. Stäckel — (All other Countries) (3).

The most important data and remarks contained in these three reports have been summarised in the following statement.

A. — General. — Extent of application and object of train control.

Changeable signals for giving the necessary information to the train staff to ensure safe operation have reached a high stage of development. But, however perfect a safety system of this kind may be, there always remains the weakness that a number of circumstances can arise which render it difficult or even impossible for the driver to discern the signals properly. Difficulties of recognition may result from poor visibility due to fog, snow, steam, restricted field of vision caused by the large boiler diameter of modern locomotives, the possibility of confusion when many signals are grouped together, etc. But serious accidents have even resulted when the sighting conditions have been quite satisfactory, due to the fallibility of the driver, for example, temporary absent-mindedness, diversion of attention by other duties, bodily and mental affections, and similar circumstances, all of which seriously endanger proper observation of the signals.

Numerous accidents traceable to the ignoring of signal indications have occurred in many countries. Even though these form an insignificant proportion of the total number of accidents, they have often had very serious consequences. It is not surprising, therefore, to find that there is a steadily increasing movement, especially in countries where such catastrophes have occurred, in favour of a direct automatic control from the track to the train as a means of attaining a higher standard of safety.

Other countries which have little or no experience of accidents due to overrun-

(1) *Bulletin of the Railway Congress*, Mai 1932, p. 705.
(2) *Bulletin of the Railway Congress*, October 1932, p. 2023.
(3) *Bulletin of the Railway Congress*, Mai 1932, p. 811.

ning of signals, naturally view automatic train control with little interest. For example, the Finnish, Netherlands, Dutch Indies, and Danish State Railways, together with many other lines, state that up to the present they have not experienced any need for the adoption of such a costly system as automatic train control. The Czechoslovakian State Railways propose to go further into the question only when they have carried out all the necessary improvements to their signal and block systems, but they have already prepared specifications for the eventual introduction of automatic train control. The point of view that automatic train control is only justifiable on routes where the safety arrangements have been brought to a high stage of perfection, is of some interest.

Apart from the question of operating requirements, the matter of cost is obviously an important item amongst the factors which tend to restrict the extension of the automatic train control system. Mr. Vlaikoff gives, in his report, a formula which is intended to incorporate the operating and economic factors which determine the urgency of the need for introducing automatic train control; in this it is assumed that the risks due to overunning signals increase in proportion to the maximum speed (V in km. per hour) the number of pairs of trains in 24 hours (P), and the number of advance and home signals (S) that have to be observed on the average in every 10 km. The cost of automatic train control is expressed by the value K. The formula is as follows :

$$C = \frac{V.P.S}{K} \geqslant X.$$

If C is found to be greater than the empirically determined figure X, the introduction of automatic train control can be considered justified on operating and economic grounds.

This formula brings into special prominence the need for train control on urban rapid transit lines where P and S have high values. This theoretical result is in agreement with the actual facts, since automatic control is used more, relatively, on the metropolitan than on surface routes.

If we now turn from the large number of railways which are not disposed to adopt train control, to the group of lines that are definitely in favour of it, the most important of the European systems are the French Railways and the Great Western of England. Both of these have adopted automatic train control on a considerable scale; the same attitude holds goods on the German State Railways who employ the system for their fast electric metropolitan services in Berlin and Hamburg. Experiments on a large scale are being carried out on the Belgian National Railway Company and on several express routes of the German State Railways; preliminary experimental work on a smaller scale is engaging the attention of the Italian State Railways, the Swiss Federal Railways and the Southern Railway of England. So far as can be ascertained the only country outside Europe in which automatic train control has gained a footing is the United States of America. No detailed information is given in the reports with regard to the extent of the installations in that country, but it is known, from information published in the Technical Press, that various systems have been tested there on a large scale, and a number of lines have now been equipped with apparatus for automatic train control.

It is clear from Mr. Crook's report, which contains a summary of the earliest English patents on the subject, that automatic train control engaged the attention of inventors of safety appliances prior to the modern development of signal and block apparatus. The earliest of the patents referred to dates from the year 1855. The aim at that time

was to devise a means of direct communication between trains without the intervention of signals.

Nowadays any system of automatic train control has naturally to be correlated to the existing signalling system. The actuation of the train controlling device has therefore to originate from the movement of the signals or from the signal operating mechanism.

The latter method offers the possibility of doing away with signals erected on the track and employing sign boards to mark the stopping places that have to be observed when necessary. This procedure is known to have been employed on certain routes in the United States, limited of course to the block signals. But up to the present, there are only isolated cases where the method is in use; generally speaking, railways that have introduced automatic control have retained their existing fixed signals intact. Mr. Crook views this opposition to the doing away with fixed signals as a traditional and sentimental attachment to past usage, but he agrees, nevertheless, that there are two important reasons why they should not be eliminated :

1. If the automatic train control system should fail, the driver would have no information as to the operating conditions;

2. There would no longer be the same compulsion to keep a look-out on the track.

But since the possibility of abnormal causes of delay always exists (e. g. obstruction of the track due to an accident on an adjacent road), a sharp look-out must be constantly kept on the road, and it certainly appears that safety would be diminished if fixed signals were dispensed with.

The German report is opposed to the removal of fixed signals, for the reasons already cited, and is supported in this attitude by the policy laid down by the Czechoslovakian State Railways.

The purpose of automatic train control in the opinion of railways which make use of it, is not that it shall act as a substitute for some part of the driver's activities. They view it rather as a supplementary system that will intervene in the event of the driver failing to maintain a proper look-out. They have in mind the possibility of the automatic control system itself failing — in the initial stages this may occur much more frequently than lapses on the part of the driver —, and that such failures in the technical appliances must be guarded against by human alertness. The possibility of simultaneous failure both of the driver and the automatic appliances will be rendered more and more improbable by the attention that is being given to increasing the reliability of automatic train control systems. Moreover, in most systems, special steps are taken to avoid any tendency for the driver to become less observant as the result of a false sense of security being engendered by technical devices.

An important distinction between the method of operation of the train control system is that some railways do not provide for the air brake to be acted upon and consider the so called cab signals sufficient, whereas another group arrange for the train control to act directly upon the brakes in case of danger. But, at the same time, in the latter case also, the principle is maintained of avoiding altogether or restricting as much as possible any interference with the working or braking of the train so long as the driver carries out his duties correctly.

Other variations in the purpose achieved by automatic control arise from some systems aiming at ensuring the observance only of stop signals, whereas others have regard to the possibility of enforcing observance of speed restrictions on curves and reduced-speed stretches of line. Experience of accidents on the larger European railways

during the past decade can certainly lead to the conclusion that the non-observance of speed restrictions on signals may be the cause of serious accidents just as often as the ignoring of stop signals; extension of automatic train control to speed limits would therefore greatly increase its utility.

The ultimate objective that can be visualised for train control is the remote control of driverless trains. Its application in this way for a special service, namely for postal transport, has been successfully carried out on the London Post Office Tube Railway described in Mr. Crook's report.

B. — Types (methods of transmission to trains).

The most important and most difficult part of automatic train control is the transmission of indications from the signals and other apparatus in the track to the travelling train.

The methods dealt with in the reports may be classified under two groups, those with mechanical transmission and those with inductive (non-contact) transmission. The following belong to the first group :

I. — *Stop devices of a purely mechanical kind.*

The transmission in this type is brought about by the displacement of a lever, which projects from the vehicle, when it comes into contact with a stop fitted on the track. Information is given in the reports on the following devices of this type :

1. A stop device with contact lever hanging vertically from the vehicle. This design is employed to a considerable extent on metropolitan lines, e. g. in North America, Great Britain and Germany, and predominantly on underground lines. Doubt is expressed as to its suitability for trunk routes.

2. The Reliostop (experiments on an un-named English railway).

3. Stop device of Siemens-Schuckert, widely employed on the various metropolitan electric lines of the German State Railways.

Types 2 and 3 resemble one another in that the train lever is fitted horizontally at a fixed height above the top of he rails, and the track stop is arranged close to the side of one rail. This arrangement affords a reliable safeguard against abnormal release from snow, ballast, etc. Both systems are being developped with a view to their application to higher speeds by the introduction of springs and other devices.

II. — *Electromechanical types.*

The purely mechanical stop systems referred to above must have the track stop either connected to the signal operating mechanism, or actuated by a separate operating mechanism, in order that the stop may be moved out of the path of the train lever when the signal is off. Operating mechanisms of these kinds, which entail certain constructional and maintenance expenditure, and in some circumstances necessitate further supervisory devices, are eliminated by the electromechanical type.

The track stop is a slightly inclined ramp (crocodile), fixed between the two rails. A lever or brush on the vehicle makes contact with the ramp, irrespective of the signal indication. The indication is transmitted to the vehicle by means of an electric current taken from a local supply, and the circuit is made or broken, or the direction of current reversed, by a contact device on the signal.

Descriptions are given of the electromechanical systems in use on the following railways (1).

(1) The various types are numbered consecutively irrespective of any classification under particular groups.

4. Nord Railway (France); 5. Nord-Belge (Belgium); 6. Midi Railway (France); 7. Paris-Orleans Railway; 8. French State Railways; 9. Paris-Lyons-Mediterranean Railway; 10. Belgian National Railway Company; 11. Great Western Railway (England).

Designs 4 to 10 operate for the most part with contact brushes on the vehicle; in design 11, on the other hand, a compartively heavy and rigid contact shoe is employed. The electromechanical system appears to be subject to the disadvantage that frost and ice are liable to interfere with the electrical transmission between the ramp and the receiver contact.

To combat this, some designs employ the « anti-hoar frost » ramp which is shaped so as to contain a supply of paraffine which maintains a coating over the surface of the ramp. On the Paris-Orleans Railway an experimental design of ramp with « louvre blades » has been employed recently, with which the use of paraffine is no longer necessary.

System No. 11 differs in another important respect from types 4 and 10. The latter are designed on the intermittent current principle, and consequently become inoperative if the current supply fails; the permanent current or closed circuit principle has been applied to No. 11. In this case, the raising of the contact shoe as well as the electric current is used for the automatic control. The locomotive actually carries a battery generating a permanent flow of current. As soon as the latter is cut off by the raising of the contact shoe, the automatic control in brought into operation. But if the current supplied by the track battery gets on to the locomotive through the ramp, as, for example when the signal is in the « line clear » position, this additional current prevents the automatic control from operating. When the transmission of current is interrupted, the automatic control acts, so that it operates in the safe direction.

The following designs belong to the second group inductive systems (without mechanical contact):

III. — *The intermittent inductive systems.*

The following are described in the reports :

12. The American intermittent inductive auto-manual system of the General Electric Company;

13. The Indusilor system of the German State Railways;

14. The Signum system of the Swiss Federal Railways;

15. The experimental system of the Italian State Railways;

16. The Strowger-Hudd system in experimental use on the Southern Railway of England.

Systems 12 to 14 are based on the same fundamental idea, and depend on the closed circuit principle. A circuit on the locomotive is energised from a source of supply on the vehicle itself. Connected in this circuit is the coil of the locomotive magnet which picks up the impulses and a control relay whose armature is normally held on. Each transmitter on the track consists of electromagnets fixed to the sleepers in such a position that the locomotive magnet muss pass over them with a certain clearance. Normally the track magnets are not energised and, therefore, no electric supply is needed. The iron core of the track magnet, by absorption of lines of force, disturbs the magnetic flux from the locomotive magnet, thereby weakening the excitation current sufficiently to cause the armature of the relay to drop. This movement of the armature is utilised to give the necessary indication on the locomotive.

By providing the track magnets with a winding connected to a contact on the signal, the track magnet is rendered inoperative so long as the signal is in the

« off » position. In common with the electromagnetic systems, this design obviates the necessity for separate control gear in the automatic control transmitting installations.

Whereas designs 12 and 14 employ direct-current for the locomotive circuit, design 13 uses alternating current. By using three different frequencies, three distinct indications can be given at each transmitting point on the track. In design 12 similar selective action is obtained by the addition of unwound track magnets.

Design 15 differs from those already mentioned in that it is based on the intermittent inductive principle. The impulse is transmitted from the track to the locomotive by means of two magnets, one a permanent magnet and the other an electromagnet. The latter is energised from a local supply source, and the circuit is broken when the signal is in the « on » position. When both the magnets are operative at the same time, a visual indication « line clear » is given on the locomotive; if, contrariwise, the permanent magnet operates alone the driver receives audible and visual warnings. Warning is given also in the event of the current supply failing.

The Stowger-Hudd system (No. 16) is based on similar principles to No. 15.

A special advantage of the inductive methods of transmission is that they are unaffected by weather conditions.

IV. — *The continuous inductive system.*

As pointed out in Mr. Crook's report, intermittent systems have a somewhat lower efficiency than the visual fixed signals in clear weather. The latter can often be seen from a considerable distance. If the signal indication changes during the time that it is under observation, the driver can immediately take action, at any time before the signal is reached. As a rule, the details of the intermittent systems are, it is true, now designed so that the driver is not deprived of this facility; nonetheless, when weather is dull, or there is any other obstruction to good visibility, he will not become aware of a change in the signal indication, in time. The permanent indication given by the continuous inductive system therefore has the advantage that the driver is informed immediately of any change in the signal indication at all points during the approach to a signal, irrespective of the visibility conditions; a time saving may result.

In the continuous inductive systems that are in use, the running rails are utilised for conveying the indications to the locomotive. The American systems below have been described; they are usually employed in conjunction with automatic block signals :

17. *Continuous inductive system U. S. S. with three indications.* — Two superimposed track circuits operating with alternating currents are employed. One of these is the familiar track circuit for the block signals, which carries a current from the source of supply along one rail to the block relay and returns by the other rail so long as no train is in the block section. If the section is occupied, the current does not pass through the block relay, but flows through the first locomotive axle to the return rail, and to the source of energy.

At the front of the locomotive is fixed an inductive receiver, through which a relay on the locomotive can be operated by the block current. This relay has three positions : *danger, caution* and *line clear.* The relay moves to the danger position when the block current is interrupted, either due to the block section being already occupied, or by reason of some fault, such as a broken rail. But so long as the block current reaches the locomotive the relay will take up either the *caution* or the *line clear* position. The change from the first position to the second is effected by the aid of another

current, known as the control current; this current differs from the block current by flowing along both rails in the *same* direction, a separate return conductor to the source of energy being used. This current acts upon inductor coils fixed at the rear end of the locomotive. It is controlled by a contact on the block relay of the following block section, in the same way as the automatic signals, and an interruption of this current shows that that section is occupied.

18. *Continuous inductive system U. S. S. with 4 indications, also known as the Code system.* — In this system the track circuit current only is used for giving the automatic control indications, which are picked up by means of two induction coils fixed just in front of the leading wheels of the locomotive and above the rails. As with the Indusilor system on the German State Railways (No. 15), the object has been to obtain several indications by variations in the current. Whereas in the Indusilor system the frequency of the current is varied, in the U. S. S. system the alternating current which is at a steady frequency of 100 cycles per second is interrupted at regular intervals. The frequency of these interruptions is different for each indication (180, 120, 80 and 0 pulsations per minute). Relays that respond to these rates of fluctuation are mounted on the locomotive. The number of indications can obviously be increased still further if required.

With both these continuous systems, the loss of energy in the inductive transmission from the track current is so great, that the relays on the locomotive can only be operated by the aid of valve amplifiers placed on the locomotive. There does not appear to be any definite conclusion at present, as to whether the advantage of continuous inductive control in giving immediate warning of any change in signal indication, of rail breakage or other track disturbances, is not counterbalanced by its increased cost and greater delicacy.

V. — *Optical train control.*

In the optical system the space between the locomotive and the track is bridged by means of a narrow beam of light. The only installation of the optical train control system is that fitted experimentally on sections of the German State Railways; it is the Opsi system of Bäseler-Zeiss, which has been developed on the intermittent principle. Since the installation and upkeep of adequate sources of light on the track would be a very costly matter, the Opsi system provides for an electric projector on the locomotive, which is operated from a turbo-generator that also supplies the locomotive lighting.

This projector delivers a steady beam upwards in an approximately vertical direction. At each control point a mirror is mounted on a bracket support at about 4 m. (13 ft. 1 1/2 in.) above rail level, and the beam is thereby reflected back to a definite spot on the locomotive receiver. The light is caused to converge by a lens on to a selenium cell which, under the influence of the light, in turn causes the circuit of an actuating current to be closed. This current is amplified by means of several valves and finally causes a relay to operate and give the desired indication. It will be seen that the transmission of the indications is based on the intermittent current principle.

When the signal is in the *off* position, the operation of the optical device is prevented by rotation of the mirror at the transmitter point. Where the mirror is close to a signal located near the track the rotation of the mirror can be arranged in a simple manner by connecting it to the signal mechanism. In other places more costly control devices are needed.

Each mirror along the track has therefore a working position and a neutral

position. The working position can be varied at the different points on the track by providing a number of reception lenses on the locomotive receivers, and in this way a number of different indications can be given. In this respect, the system is as flexible as the American U. S. S. code system.

VI. — *General remarks.*

Two kinds of faults can occur in the transmission of the impulses; failure in the transmission, and the reception of false or untimely impulses. Although improvements must necessarily be directed in the first instance towards the complete elimination of failure to receive intentional indications, there is no room for permitting the occurence of unintentional indications, since these would give unnecessary concern to the engine driver, and if they become frequent would lead to the cutting out of the entire train control equipment.

Solutions of the transmission problem have been sought in many directions, their diverse character resulting from variations in climatic conditions and the special features of the track. Mechanical and electromechanical installations with ramps of the crocodile type are principally suitable for use in countries where there is little snow and frost; they require, moreover, ample clearance below the vehicle, and this is not available on all railways. The difficulty of fulfilling this condition has led in Germany, as it had previously done in the United States of America, to the cessation of the experimental contact ramps, in favour of non contact systems.

There is no uniformity of opinion on the question of the steps that should be taken to prevent failures of the automatic train control apparatus. Some railways consider it sufficient for the driver to assure himself that the apparatus is working normally at caution signals; others tend more or less to giving the driver immediate indication of any fault in the operation. Such an indication can only be given in a simple manner if the disturbance is allowed to produce a control impulse. With systems in which the brakes are acted upon (see next section), the introduction of this feature means that the brakes are applied in the event of any fault occurring. This most undesirable state of affairs as regards train working can be rendered harmless at the sacrifice, it is true, of other desirable features.

Further reference to this all-important question will be made at the end of the next chapter.

C. — Methods of operating automatic train control system.

Next in importance to the technical question associated with the transmission of the impulses, is the practical incorporation of the system into the existin signalling and operating system. The following problems require special attention, and have been solved in various ways :

a) The location of the transmitters in the intermittent inductive system in relation to the signals,

b) The use of the control impulses (cab signals, brake operation),

c) Maintaining the alertness of the driver.

When settling these points the technical possibilities that are inherent to the impulse transmission system selected are often the deciding factor. Systems which provide for the giving of several different indications afford the fullest scope for the attainment of the desired standard of operating safety. From the point of view of the location of the transmitters, the automatic train

control systems may be classified as follows :

1. *Train control at the home signal.*

Most of the notifications on metropolitan lines belong to this group, as also the Siemens-Schuckert train stops used on the German State Railways. In these systems the control occurs at the *home signal,* and it comes into operation only on overrunning of the signal when it is at danger. The brakes are brought into operation, and on electric lines the traction current is cut off. In order to provide complete security against accidents, it is necessary, with this scheme, to place the home signal at a distance in front of the danger point equal to the braking distance; such an arrangement appears to be practicable only on particular routes where the speed is limited and all trains have a short braking distance. Hence, on fast train routes, and other trunk lines operating mixed services, only the systems referred to later, can be considered.

As with the scheme outlined above the automatic control only acts in the event of a definite state of danger arising, and does not act so long as the driver is carrying out his duties properly, there is no objection to the direct and unconditional operation of the brakes. This is not the case with the automatic control systems described later on, which come into action *before* the home signal is reached. With these schemes, unconditional automatic braking would constitute an interference with the driver's duties. In the following scheme (2) this difficulty disappears in that the brakes are not operated upon automatically.

2. *Control at the distant signal without actuation of the brakes.*

This system, which has the advantage of simplicity, has been installed on the French Railways, the Belgian National Railway Company and the Italian State Railways. If the train runs past a distant signal that is in the *caution* position, the control apparatus sets into operation on the locomotive, usually by compressed air, a loud warning siren which can be heard not only by the locomotive crew, but also by the guard. The driver has to operate an acknowledging lever just before coming to the transmitter. This operation and the automatic control impulse are registered on a recording device that is connected to a recording speed indicator of the Flaman, Haushaelter, Hasler or other type. This ensures that the acknowledging lever is operated before the control indication is received.

3. *Control before reaching the home signal with actuation of the brakes.*

In the systems described under this heading interference by the automatic control with the driver's duties is avoided, by arranging that the actuation of the brakes is conditioned by certain circumstances. Three methods of effecting this are available; the vigilance principle, the speed restriction principle, and a combination of these two.

The *vigilance principle* is represented in its simple form by the systems in use on the Great Western Railway, the Swiss Federal Railways, and also the U. S. S. continuous inductive system using four frequencies. If the train runs past a distant signal that is in the *caution* position, the brakes are applied and the cab signal is actuated. The driver can, however, cancel the effect of the automatic operation by means of an acknowledging plunger, or even prevent their occurrence. In the U. S. S. continuous inductive system the possibility of the driver doing this is restricted by a timing device which prevents cancellation after the lapse of a definite interval.

The *speed restriction principle in its simple form* is represented by the method of operation underlying the Opsi system. The main idea is as follows :

In the event of a train having to be brought to a standstill at a home signal, its speed is previously restricted from point to point in accordance with a definite braking curve. For this purpose, control apparatus is installed at several points between the distant and home signals and these operate so as to apply the brakes if the speed at which the particular location is passed exceeds the predetermined value. As no interference takes place so long as the driver carries out his duties correctly, it is not necessary to provide a device which would enable him to cancel the actuation of the brakes.

As already described in Chapter B, the Opsi apparatus makes use of beams of light which impinge on different points in the locomotive receiver at the respective transmitter locations. By means of a device operated by a tachometer on the locomotive, those receiving lenses are screemed which correspond to higher speeds than that indicated at any time by the tachometer. For example if the train is running at 40 km. per hour, a beam of light which is set for a speed limit of 60 km. per hour cannot enter the apparatus on the locomotive.

The Paris-Orleans Railway carries out some experiments with the Rodolausse locomotive equipment, which also acts on the compressed air brakes and can be used in conjunction with the electromechanical ramp and other types of pick-up, as well as being suitable for installation purely on the speed restriction principle. It is capable of being set to various speed limits, without having to transmit different impulses at the various automatic control points. Two ramps are therefore arranged one behind the other, the interval between them being varied at the several control locations in accordance with the particular speed limit that has been assigned. The relation between the speed, the actuation of the brakes, and the distance between the two crocodiles is determined by a combined distance-and-speed indicator.

Whereas in the vigilance control system it remains possible for the driver to nullify the operation of the train control without further reduction of his speed, with the straight speed principle it is possible to enforce the stopping of the train at a signal that is in the danger position. A special feature of this system is that, if a driver passes a distant signal which has given him caution, he is prevented from accelerating again, by mistake, past the *home signal,* which, it is true, may have changed its indication during his approach. Although the straight speed principle is theoretically perfect, it has not yet been used very much; it requires more transmitters along the track than the vigilance control system. Moreover, owing to the various classes of locomotive and brake equipment, it is not an easy matter to assign the correct speed limits which will eliminate unjustifiable interference with the driver's operation of the train.

A *combination of the vigilance control* and the *speed restriction principles* is found in the method of operation of the Indusilor system of the German State Railways. In advance of each home signal are three transmitters, the first at the distant signal, the second at an intermediate point and the third at the home signal. That at the distant signal actuates the brakes after the lapse of a definite interval during which time the driver can prevent their operation by making use of the *vigilance control key.* However, once the brakes have been applied, they cannot be released until the train has come to a standstill. A visual or acoustic device for attracting the driver's attention is not provided. At the second, i. e. the intermediate point, the brake is applied if the speed exceeds a predetermined limit, and this occurs similarly at the home signal if it is overrun when in the danger position.

With a system of operation of this kind, in which care is taken to avoid special features which might tend to minimise the alertness of the driver, the actuation of the brakes can only be released under abnormal circumstances, after the train has been brought to a complete standstill. This feature is based on the assumption that unintentional automatic control operations are likely to occur only in rare and exceptional cases; otherwise the danger would exist of the driver putting the automatic control entirely out of service by means of the indispensable main cut-out switch.

In other respects, however, the Indusilor system in its present form ensures with a large measure of certainty that the train will be stopped before or immediately at a home signal, in the event of faulty driving. The operation of the vigilance lever, as well as the operation of the automatic control apparatus, are kept under supervision by a recording device.

In the Strowger-Hudd system of the Southern Railway, which has been developed with similar objects in view, if the home signal is at danger an audible cab signal is set in operation 60 m. (180 feet) before arrival at the distant signal, and the brakes are applied when this signal is reached. The driver can cancel these operations, but can do so only after the speed has fallen to a prescribed figure. A further application of the brakes takes place at the home signal, if this is overrun when in the danger position.

The foregoing review of the various methods of operating automatic train control systems shows that most railways consider it necessary to employ recording apparatus for maintaining a check on the alertness of the driver. The contrary attitude is adopted by a small proportion. At the same time, supervisory methods of this kind have the disadvantage that they involve greater expenditure if carried out thoroughly, and can cause dissatisfaction to the locomotive crew. On the other hand no alternative method is yet available that will reveal and prevent attempted misuse of the automatic train control system.

In spite of certain objections which might be raised against checking the vigilance of the driver, the trend of development is towards warning him as early as the distant signal by means of audible or visual cab signals, and giving him in addition the facility for cancelling the operation of the brakes by the automatic-control system, after he has received the warning. It is true that with the systems that operate on the closed-circuit principle, this facility has the advantage that application of the brakes caused by faulty working of the system can be at once cancelled out, and in this way any harmful effect upon the running of the train can be avoided. As against this, the existence of the facility has the defect that it reduces the compulsory nature of the driver's intervention; if an attempt is made to make good this effect by the addition of automatic speed control devices, as in the last schemes described, the cost and delicacy of the apparatus are increased.

In Chapter A it was pointed out that consideration is being given to extending automatic train control to junctions and sections of line to be run over at restricted speeds. In general, this is not possible with systems of a simple description giving only one or two kinds of transmission (without the assistance of speed-measuring apparatus); nevertheless, on railways like the Great Western which use the same signal aspect for a distant signal protecting a junction, as for a home signal at danger, the case of junctions is provided for if the automatic control takes place at the distant signal. Where three-aspect distant signals exist, the arrangement can be such that junctions are covered by the

automatic control with one or two indications.

Where multiple indication control is provided for, and in systems which utilise speed-measuring equipment, it is possible to take into account the cases of junctions and other sections to be run over at reduced speed.

D. — Economic questions.

The progress of automatic train control depends upon the cost of installation being reduced to the lowest possible level. If, however, in aiming at this, certain refinements are abandoned, e. g. recording apparatus, as well as complete rigidity of control, i. e. mistake-proofness, and the extension of the system to junctions, etc., the risk is incurred of certain accidents, which may unfortunately be particularly serious in spite of the existence of the automatic control system, and which might have been provided against by the use of this system. Such occurrences will be given publicity, whereas the more numerous cases in which accidents have been prevented by the automatic control system, will remain unknown and not be credited to the system. These considerations are opposed to the policy of excessive simplification at the expense of safety.

Since little data have been given concerning the cost of installation a survey of this question cannot be included. Moreover, the varying price conditions in different countries render it hardly possible to give any correct comparison of such costs.

SUMMARY.

1. The *desirability* of equipping a railway system or individual lines with train control apparatus depends amongst other things upon the train speed, the intensity of the traffic, the interval between signals and the cost of installation.

2. In developing automatic train control it has to be considered as an adjunct to the existing signalling equipment. It is intended to ensure the observance of signal indications whenever the driver fails to take notice of them, or to avoid the consequences that might result from such failures. But in the main, safe running has to be guaranteed primarily by the alertness of the driver. It follows, therefore, that generally speaking the installation of automatic train control should *not* be accompanied by removal of the fixed signals.

3. The continuous inductive system of automatic control is capable of meeting operating and safety requirements to a somewhat greater extent than the intermittent inductive system. Sufficient information is not yet available to form the basis of a decision as to whether this advantage is or not outweighed by the higher cost and greater delicacy of the continuous system. The most important operating and safety conditions can be met by the intermittent system. The continuous system should be considered chiefly in connection with lines equipped with automatic signalling.

4. The *purely mechanical* method of transmission has proved a reliable method of conveying intermittent impulses from the track to the locomotive on metropolitan systems. Where snow or other deposits on the track are liable to cause disturbances, it is desirable to arrange the transmitting apparatus at a suitable height above rail level. Difference of opinion exists as to the suitability of the purely mechanical system of transmission for fast train routes.

5. The *electromechanical system of transmission* using contact ramps has given satisfactory results in countries having temperate climates (Western Europe); in some cases, however, protection has to be provided against hoar frost. An essential condition for the employment of the electromechanical design is the existence of ample clear-

ance between the underside of the vehicle and the track.

6. Various *electro-inductive* systems have proved reliable and not sensitive to climatic conditions on fast train routes.

7. With the *continuous inductive automatic control,* only inductive transmission by the track circuits can be considered at present.

8. An advantage of the electromechanical and the inductive types of equipment as compared with other designs is that they *do not require any operating gear in the track.* In certain types of inductive equipment it has been possible to dispense with a local supply of current.

9. The application of the *closed-circuit principle,* in such a way that faults cause a control impulse to be given, has the advantage that the staff is more interested in the correct maintenance of the equipment, but this arrangement can lead to certain drawbacks in operation. The question as to whether the closed-circuit principle is to be applied depends on the general arrangement and the method of operation of the automatic train control system.

10. The *main purpose* of automatic train control is to absolutely ensure that the train shall stop in front of a home signal that is *at danger.* It is desirable to design the equipment so that safeguards can be applied to ensure *reductions of speed* at junctions and other places where such restrictions are stipulated. Systems which give several kinds of impulses are especially suitable for this requirement.

11. It is desirable that the system of operating automatic train control should be such that the *attention* of the driver is affected as little as possible by his being conscious of the existence of the automatic control apparatus.

12. In the case of railway services in which short braking distances are the rule, the consequences of the driver failing to comply with the signals can be fully averted by an automatic control transmitter *at* the home signal, provided that the impulse causes the brakes to be applied immediately, and that the distance between the home signal and the danger point is at least equal to the full braking distance.

As a rule these conditions are not fulfilled on fast train routes; first of all, an automatic control action *in advance* of the home signal is therefore essential in such cases.

13. With systems which come into operation *in advance* of the home signal, or at the distant signal, the arrangements can be simplified by dispensing with the brake application. Cab signals without compulsory braking, when used in conjunction with a vigilance checking device and recording apparatus, assure a notable increase in safety as compared with the conditions if no automatic train control were employed.

14. In order to prevent the possibility of improper driving beyond the advance signal, *in spite of a caution indication having been received,* it is desirable that *application of the brakes* shall also occur with automatic control transmitters *in advance* of the home signal. Only when danger exists, however, should braking be continued up to the point of complete stoppage; contrariwise, when the driver is running according to regulations, control of the speed should remain in his hands.

15. For drawing attention to the possibility of danger, either a vigilance checking device, or an arrangement for graded speed checks are available. The *vigilance* check in the vicinity of the distant signal can be supplemented by a speed check that comes into operation later.

16. The *vigilance checking device* must enable the driver to prevent the

brakes coming into operation in the neighbourhood of a distant signal. It may be an advantage, from the point of view of maintaining smooth operation, if in addition, it is possible to release the brakes subsequently.

However, the alertness of the driver is better guaranteed if braking continues to the point of standstill, after he has failed to apply the vigilance checking device, and release of the brakes can only be effected when the train has stopped.

17. The desirability of making the automatic control impulses perceptible, by means of *visual* or *audible* signals, in systems which include application of the brakes, depends in turn upon the relative importance that is attached to maintaining the flow of traffic or to enforcing alertness.

18. With a view to maintaining proper supervision over the use of the vigilance checking device and the existence of the control impulses, it is recommended that *recording apparatus* should be fitted which should if possible record the speed and indicate the location at which each event has occurred.

19. It is not yet clear whether automatic train control systems are satisfactory which do not use a vigilance check and rely solely on *graded speed restriction control.*

20. Designs which embody unconditional braking at a danger signal require a cancelling-out device so that in the event of *signal failures* it may be possible to run past a signal which is at danger.

21. It must be possible for the driver to cut out the automatic control apparatus in the event of faults occurring in the equipment on the engine.

22. Automatic train control is an important complement to the safety precautions. Its introduction is recommended on routes where it appears necessary in the light of the considerations of paragraph 1, as far as permitted by economic conditions and other requirements.

[385. 524 & 385. 587]

SECTION IV. — General.

QUESTION X :

Instances of the application in a railway department of the scientific organisation of work. Co-operation of the staff towards increased efficiency and its participation in the profits,

by Messrs. E. SOULEZ and M. BLOCH,

Special Reporters.

Introduction.

Question X of the Agenda for the 12th Session of the International Railway Congress has formed the subject of three reports as under :

Report No. 1. — Messrs. E. Soulez, Ingénieur en chef attaché à la Direction de l'Exploitation, French Nord Railway, and M. Bloch, Ingénieur en chef des Services du Matériel et des Ateliers, Paris-Orleans Railway, for Belgium, Spain, France and their Colonies, Great Britain, Dominions and Colonies, Luxemburg, Netherlands, Portugal and their Colonies (1).

Report No. 2. — Messrs. L. Tosti, Ingénieur en chef supérieur au Service du Personnel et des Affaires générales, Chemins de fer de l'Etat italien, Rome, and C. Valeri, Ingénieur, Inspecteur en chef supérieur du Service du Matériel et de la Traction, Chemins de fer de l'Etat italien, Florence, for all countries except Spain, Portugal, France, Greats Britain, its Dominions and Colonies, Belgium, Luxemburg, Holland, Denmark, Norway, Sweden, Finland, Germany, Switzerland, Czechoslovakia, Bulgaria, Greece, Rumania, Jugoslavia, Turkey and Poland (2).

Report No. 3. — Messrs. Mereutza, Ingénieur, Inspecteur général, Sous-Directeur général des Chemins de fer de l'Etat (Rumania), and Panaitopol, Ingénieur, Inspecteur général, Directeur supérieur des Chemins de fer de l'Etat (Rumania), for Denmark, Norway, Sweden, Finland, Germany, Switzerland, Czechoslovakia, Bulgaria, Greece, Rumania, Jugoslavia, Turkey, Poland (3).

This question X on which we are reporting to the present Congress must be considered as being complementary to Question XV which was considered and discussed at the preceding Session (Madrid, 1930) and entitled « Co-operation of the staff towards increased efficiency and its participation in the profits ».

In the examination of the latter question it was found that the terms in which it was expressed had given rise to differences of interpretation on the part of the Reporters, and the conclusion of the Congress on the subject took the form of a desire that the question should be given as wide a scope as possible and reported on afresh to the 1933 session.

This desire was subsequently given effect to by the Permanent Commission

(1) See *Bulletin of the Railway Congress*, July 1932, p. 1329.
(2) See *Bulletin of the Railway Congress*, July 1932, p. 1211.
(3) See *Bulletin of the Railway Congress*, October 1932, p. 1923.

of our Association, who decided that co-operation of the staff towards increased efficiency should be further examined in all its aspects, for which purpose Question X of the present session, regarded as a continuation of Question XV of the Madrid Congress, was worded as follows:

Instances of the application in a railway department of the scientific organisation of work. Co-operation of the staff towards increased efficiency and its participation in the profits.

It will thus be seen that the subject has become considerably widened.

Following the example of the reporters, the special reporters feel it necessary to remark, at the outset of their report, that the replies furnished to the respective questionnaires issued on this subject were not so numerous as might have been expected. A large number of administrations did not reply at all, while several of those that did, merely dealt cursorily with the subject, and the consequence was that certain of the reporters were seriously hampered. In the 2nd Report, for instance, Messrs. Luigi Tosti and Carlo Valeri had to limit themselves almost exclusively to the measures taken by the Italian State Railways.

The reporters do not overlook the fact that the silence of a large number of Administrations must no doubt be attributed to the very difficult times through which in many cases the railways of the various countries are now passing, but they particularly regret the absence of information from certain administrations who are well known for the efforts made by them both in the direction of scientific organisation and in social and welfare activities. It is only fair to add, on the other hand, that the opinions of several of these can be found in the reports submitted to the previous session (Madrid) and we would request the members of the Congress to refer thereto in order to complete their information.

It appears, moreover, from some of the replies themselves that several administrations have not thought it worth while giving particulars of experimental arrangements which have not been operating for a sufficient length of time to be proved satisfactory. It must not be forgotten that results are never immediate; such measures are always hampered, at least in the beginning, by various factors of a local, personal, and also financial character, especially under existing conditions. Be that as it may, the special reporters consider that, on the whole, sufficient information is now available regarding the developments to which this question has given rise, to enable the Congress to form conclusions.

The first part of the question under notice, i. e., that relating to scientific organisation, has taken on a special importance at the present time by reason of the upheavals in world economic conditions, and this is brought out by the Italian reporters when they state that « even in the particularly critical moment they are passing through, the railways take steps to extend the application of the most important and best known principles of organisation to every branch of their activities ». That the results obtained in this connection are already considerable is shewn by the very detailed way in which the reporters have dealt with this subject (1).

With respect to the first part of the questionnaire, we must refer here to the

(1) As an example of these results the reporters may be permitted to cite the report of the Nord Railway, of France, to its shareholders, in which it is stated that for the year 1930 the operating ratio was 80.84 %, whereas it would have been 107.45 % if the same methods of working and the same plant as were used in 1913 had continued to be used in 1930.

essential implication lying at the root of the conclusions of the Rumanian reporters, i. e., the need for harmonious co-ordination between the various means of transport.

In our opinion, this co-ordination must primarily be based on the economic conditions appertaining to each means of transport, and consequently on the normal and rational possibilities afforded by each; but if the results are to be genuine it is obvious that the external charges borne by each, particularly fiscal charges, should first be placed on a basis of equality. We have also thought it desirable to refer again in our general summary to the necessity for such co-ordination.

As regards the second part of the questionnaire, which principally concerns social and welfare work, other factors have engaged the attention of the railways. These are, in particular, the need for the employers to study the living conditions of the men they employ. The replies received shew that the efforts of a psychological character and the pecuniary sacrifices made for improving living and working conditions have not been made in vain, and that the feeling of regard of the staff towards their system has produced beneficial effects from every point of view.

It must not be concluded from the foregoing that we consider Question X as comprising two distinct parts with few points in common. It point of fact, the rationalisation of railways and the development of staff measures appear to be complementary tasks which must be undertaken correlatively and which have indisputably mutual aspects. Thus, scientific organisation raises the standard of every man's work both intellectually and manually, and, reciprocally, measures devised for creating a feeling of regard on the part of the men, particularly the development of social and welfare work, invest the railways with employees who are not only attached to their service but of a high technical and intellectual standard, and consequently able to take a part in the improvement of methods aimed at by rationalisation.

It appears, therefore, that in practice these two questions are inseparable, so that an administration which only concerned itself with one of them would be leaving a part of the problem untouched.

PART I.

Financial, administrative and technical questions.

I. — General.

With the foregoing principles enunciated, we will proceed to give a brief analysis of the three reports, which have been drawn up on very similar general lines, consisting, as directed in the heading of the question, of an examination of instances of scientific organisation, followed by a review of staff co-operation towards increased efficiency.

Scientific organisation has an enormous field of application, extending from the general organisation of a railway, where its special concern is the co-ordination of the main cogs in the machinery, right down to the smallest detail of the methods to be employed in the execution of manual work, and it was for the purpose of simplifying the task of the reporters and facilitating the discussion at the Cairo Congress that the Permanent Commission confined the question to « instances of the application of scientific organisation », so that the reports could thus be limited to a few typical cases.

Having regard to the object of special reports, which is to provide an outline for the discussion at the Congress, the special reporters have not deemed it necessary to cite every example of scientific organisation described by the reporters, but have endeavoured to extract the broad principles, and, one might

almost say, the under-lying philosophy of the reports.

II. — General organisation of railways.

The general organisation of a railway system would seem to be the result of complex factors among which may be distinguished the following:

— the original formation and subsequent evolution of the particular railway;

— the local conditions affecting the nature of the traffic (industrial, agricultural systems, etc.) or the special difficulties of working (mountain systems);

— the nature of the staff employed — a particularly important factor in the case of colonial railways;

— the extent to which the railway is the result of amalgamations.

It is the past or present effect of any or all of these influences which have given the various administrations the general organisations by which they are characterised, and which in their broad principles are based either on the decentralisation or the centralisation of administrative offices, that is to say, either on geographical division throughout or on division from top to bottom, into great technical departments.

It appears, however, that the questions dealt with by a railway can be divided into :

— regional questions concerning daily working,

— technical questions of a general nature, and

— financial questions.

On the whole, the first category of questions are settled by regional offices and the second by large general departments, the last being the province of the general management. The result of this distinction is a general plan of organisation which has been adopted by each system, but actually these questions are apparently not so easily settled as, in practice, the lines of demarcation between them are not always clearly defined, and a certain amount of mutual overlapping exists between the general, technical, and even the financial, functions. Be that as it may, the railways which have given the main outlines of their general organisation do not seem to feel any need for change.

The following points should be noted in connection with this subject :

a) Contrary to what may be thought *a priori*, it is not wholly advantageous to group on too large a scale, whether in the case of a department, a railway or even a number of railways. Economists have always pointed out the inherent defects of too large undertakings, and it is not necessary to look far beyond the field of railway activity to find recent examples confirming this opinion. Railways, however, being destined to provide long-distance conveyance, it has been found expedient to create national or international co-ordinating organisations for dealing with inter-railway questions, which shews that the necessity for national and international co-ordination is keenly felt in the railway world;

b) The essential need in the organisation of such a large enterprise as a railway system is for liaison between its various departments. For this purpose recourse is had to conferences between the heads of departments or the qualified officers of common organisations.

From the material point of view the solution of efficient co-ordination is to be found in the rational arrangement of offices, and the use of up-to-date equipment such as telephones, pneumatic tubes, etc.

c) The organisation of the commercial departments of the various railways merits special mention. There is no doubt that the development of the competition with which the railways are at present contending is an incentive for

each railway to provide its commercial department with the most suitable equipment, whether material or otherwise and to give it the maximum of initiative and efficiency.

d) The leasing of certain services, etc., to others undertakings, thanks to interested management, gives financial results to be desired, particular attention in this respect being drawn to the results obtained therefrom by the Italian State Railways, which are dealt with in some detail in the report of Messrs. Tosti and Valeri.

e) When entering into the question of the organisation of the executive serices of the railways, one is immediately struck with the difficulties inherent in enterprises which, by their very nature, have to distribute their establishments over territories which at times are of vast extent. In this matter the railways find themselves at a particular disadvantage as compared with other industries, which are able to confine their controlling centres to the smallest possible number of points, or even to operate from a single centre.

From the commercial point of view it is frequently desirable for a railway's establishments to be as widely dispersed as possible in order to be easily available to users, provided, of course, that the cost of doing so is not out of proportion to the object in view. From the technical point of view, on the other hand, it appears to be of advantage to group the various traffic, etc., services of the railway into a limited number of special and well-organised centres, despite the complications which this system involves from the point of view of transport and co-ordination.

It seems that the present tendency is in the direction of limiting the number of establishments as fas as possible, the number varying of course according to the size of the railway.

III. — Administrative organisation.

The quest for the best general organisation is bound up with that for improved methods of carrying out administrative work. The quality and the rapidity of the intellectual work of the heads of departments and their assistants depends essentially on the working of the administrative machine, which must supply particulars, reproduce documents, check the contents of the latter and finally allocate them.

Improvements in administrative work are hence of two kinds : organic and material.

In the organic field, a better standard of efficiency will be obtained by the regrouping of offices, the concentration of similar duties in specialised offices : typing office, filing office, accounting office, etc., the revision of service instructions in order to detail the work of each member in regard to compiling and dealing with the various statements, etc., and finally by supervising the execution of the orders given. As regards the latter point we would lay particular stress on the importance of supervision on the spot, which enables defects in working to be perceived much more vividly than can be done through the medium of a report.

The chief officer will, of course, possess statistics and graphs which often enable him to foresee events and in any case to follow the general activity of his department, but this is not sufficient, and serious defects may escape his notice if he and his assistants do not themselves inspect the actual operations. Mention may also be made of the special care with which each chief officer should follow the expenditure of his department day by day and watch any departure from the annual estimates (1).

(1) See reports of the meeting held in July 1931, at the Institute for scientific organisation of labour, Geneva.

Progress as regards the equipment of offices is more or less dependent on concentration of mechanical means into specialised offices, this procedure being generally the only way to enable the fullest use to be made of modernised equipment and consequently the rapid redemption of its capital cost. Office equipment may be classified into :

— Machines for reproducing documents (typewriters, duplicating machines).

— Accounting machines.

— Machines for dealing with statistics.

— Card indexes.

— Improved filing equipment.

— Special machines.

IV. — Organisation of the working (outdoors) departments.

Before attempting to deal with the organisation in the traffic and technical working departments, it is desired to draw a distinction between improvements of an organic nature and those which are purely material.

In the first category are included improvements which relate to the organisation proper of a department or an establishment, and which consists in the revision of instructions and methods of working, the rational distribution of the supervisory staff and the best use of the manual labour for operating whatever plant is possessed.

The material improvements consist, on the other hand, in finding the equipment most adapted to the work to be effected.

In practice, these two aspects are inseparable, for it is just as incredible that an enterprise should incur the expense of installing improved equipment without endeavouring to obtain its maximum use, as that it could improve its methods of using labour without being struck by the advantages to be procured by the use of modern equipment and consequently without being led thereby to do everything within its means to make use of it.

In dealing with this question, however, these two points may be treated separately, and it appears to the special reporters that their attention should be directed for preference to a description of methods rather than equipment, which latter has been fully dealt with in the technical reviews of all countries.

a) Operating and commercial departments. — These departments include the services and establishments entrusted with the formation and running of trains (operating) and those responsible for relations with the users (commercial). On some systems they are kept as distinct as possible, being differentiated in some cases at the very top of the general organisation, but it would appear to be impracticable to maintain the separation right down to the bottom of the scale, viz., to the average and small stations, where the conditions are such that the staff are able to carry out both the operating and the commercial duties.

We will examine consecutively the station organisation, the running of trains, and the distribution of stock. These problems will differ according to whether passenger traffic or goods traffic is in question.

The organisation at passenger stations depends not only on the tracks, signals, lines and stock, but also on the internal organisation, which should permit of the optimum employment of the staff whilst providing every possible convenience for passengers. Very satisfactory results have been obtained on these principles at certain passenger stations.

Goods stations include stations for the loading or unloading of goods, and marshalling yards. At the former the problems to be solved relate primarily to questions of handling and sorting.

The problems connected with marshalling yards have for a long time been

the subject of very thorough investigation. As regards the number and position of these stations and also their layout, the railways are to some extent freed from local contingencies or traffic limitations, and have therefore, in numerous cases, been able to establish for the whole of one or several systems a general forwarding and marshalling scheme to satisfy general requirements whilst being adapted to the local demands of the area served. They have thus been able to provide for the transport of full wagon loads under the best possible conditions, and at the same time, by concentrating to the utmost their marshalling work at certain carefully chosen yards, to instal sorting or marshalling sidings equipped with all the improvements of modern technique, thereby working under the best conditions of safety, regularity and cost. Numerous and satisfactory results have been reported by the various systems in this connection.

Mention may be also made of the improved standard of efficiency obtained by the preliminary analysis of the operations to be effected and the detailing of each successive operation on cards, whereby those railways which have adopted the system have been able to reap the full advantage of modern installations. Finally, in many cases the staff has been given an interest in improving the efficiency of their yards by the introduction of premiums.

During recent years considerable progress has been achieved in connection with the running of trains, numerous examples of which have been cited by various systems, the adoption of the dispatching system or other analogous methods being the cause.

It is not necessary to emphasise the importance of the problem of so allocating the stock as to increase its effective use (thereby reducing the amount of capital tied up in rolling stock), of reducing the period of transport by supplying in a minimum of time, the user with the vehicle required, and, finally, of obviating empty journeys. Many interesting results achieved in this direction have also been reported by the various Railways.

b) Rolling stock and locomotive running. — These departments are responsible for the construction, use and maintenance of the locomotives and rolling stock. The Railways in the first place endeavoured to obtain improvements by building locomotives of constantly increasing power, which in turn gave rise to the necessity of an improved organisation for their use, as unless they are effectively employed they are more likely to cause a loss than a gain.

One of the more important problems to be solved by this department therefore, is that of the efficient organisation of locomotive running. Attention should first be directed to choosing the best type of locomotive for the traffic in question, and thereafter to arriving at maximum efficiency by using it to its fullest capacity, which in the case of goods trains means that the load should correspond as nearly as possible to the power of the engine. In order to make more use of the locomotives themselves, i. e. to increase the distance run in a given time, various methods are proposed, such as, lengthening the distance between stages by increasing the scheduled speed, or increasing the number of runs by instituting a double or triple engine staff or even complete pooling of the locomotives. Here also the attitude of the men is important, and they are nearly always given an interest in the results by the award of premiums for distance run, maintenance of locomotives, economy of fuel and oil, regularity, and, in some cases, safety.

The principle of rational organisation of locomotive depots lies in the methodical running of locomotives, facilities for their arrangement in the sheds in order to avoid any loss of time on de-

parture or arrival, and also in the mechanisation of all the accessory operations such as the handling of fuel, sand or ashes, boiler washing out, recovery of heat formerly wasted, etc., and finally provision for current repairs.

These various improvements are amply justified in important depots where a large number of operations are carried out, and where consequently the equipment enables the maximum of regularity and safety to be obtained at a low cost per unit of work.

The inspection of carriages and wagons at stations on the route is stated by several Administration to have given very satisfactory results, and the tendency should be noted of instituting periodical inspections which obviate premature repairs, e. g. through bad lubrication of wagon axle-boxes.

The cleaning and light repairs of carriages and wagons are effected in the sheds, the principles of organisation of which are similar to those explained in respect of locomotive depots. In particular, the tendency with light wagon repairs is to carry them out by a process approximating as closely as possible to the « belt » or « progressive » system.

Generally speaking, the most suitable field for the application of modern principles for the organisation of work is to be found at the large rolling stock repair shops. It can safely be affirmed that the majority of Railway Administrations have nothing to learn from other industries in this respect. The attention of Administrations has been brought to bear in the first place on the number and size of the workshops, and the present tendency seems to be to reduce the number of these as far as possible.

Efforts have also been directed to a consideration of the economical use of staff and machines, for which purpose specialisation has generally been introduced and output premiums awarded.

The stores of the rolling stock and locomotive departments have also been the subject of similar regrouping, with satisfactory results in respect of both handling and accounting.

c) *Permanent way.* — The information we have received shews that considerable progress has been realised in recent years in connection with the inspection and upkeep of the permanent way, this work often being carried out mechanically, provided with all the most improved mechanical equipment. The component parts of the track and the points and crossings, etc. are sometimes even prepared in advance in special and powerfully-equipped workshops so that nothing remains to be done on the spot except to remove the worn parts and fit the new ones after mechanical cleaning and replacement of ballast.

A large number of railways possess special workshops and stores for this description of work, whilst in order to reduce general costs certain Administrations have combined workshops or stores of the permanent way department with those of the rolling stock and locomotive department.

V. — Standardisation.

A special section is required for questions of standardisation, which although does not essentially constitute progress in itself makes an important contribution to the organisation of work. The basis of standardisation on the railways is the establishment of national or international standards, to which work the majority of administrations have contributed, subsequently conforming thereto in the construction of new stock and also endeavouring to apply them by way of renewal when repairing old stock. The principle of standardisation is also being applied to whole series of the mechanical parts most commonly used, so as to render them interchangeable. In

these circumstances the question of standardisation becomes closely bound up with that of the tolerances allowed in manufacture. Dimensional standardisation is added to standardisation in regard to quality, and this has given rise to the establishment of specifications which the majority of administrations require their contractors to observe.

The efforts of administrations have not merely been confined to standardising mechanical parts of rolling stock and plant ; it has also been extended to buildings and even to permanent way structures, the component parts such as windows, doors, iron parts or assemblies, being thus standardised.

VI. — Importance of the organisation of work.

The foregoing particular shew with what activity the railways as a whole have applied modern methods of scientific organisation, and indicate the results already obtained and those which it is hoped will be obtained. It has sometimes happened, however, that this tendency has given some cause for uneasiness on the part of the staff. On the railways, as in industry, scientific organisation has been regarded sometimes as one of the causes of unemployment. We have no intention of going into this question, which is outside our subject, and will confine ourselves merely to stating that the crises which have occurred in world economy are due to the fact that the organisation of production has not always been accompanied by rationalisation of consumption.

The railways however, which operate « on demand », cannot fall into this error, although the extent to which they are at present feeling its effect is well-known.

In their case, moreover, the reduction of expenditure is now a vital necessity owing to the competition to which they are subject by other means of transport possessing new methods of increased efficiency, such as mechanical traction on canals, considerable increase in the use of power-driven craft, use of internal combustion engines for road lorries and coaches, employment of increasingly powerful lorries with trailers which now constitute real road trains, increased power and speed of aircraft, etc.

If the railways had not acted as they have, they would have found themselves unarmed for this competition.

Furthermore, it must be borne in mind that scientific organisation means increased safety for the men employed, as it eliminates a number of operations involving special risks, protects men from the consequences of human fallibility, raises the general level of intelligence, replaces muscular by mental effort to a considerable extent, and, finally, increases their remuneration. The men benefit from the increased production and the lowering of costs, by the granting of bonuses which constitute a supplementary wage, and there has also been a partial compensation for the abolition of manual labour by the creation of new posts for supervisory staff and the concomitant increase in clerical work.

Finally, the scientific organisation of production has already been, and in future will be still more, accompanied by a corresponding systematic examination of the conditions of sale, i. e., an intensified endeavour to attract traffic and even to create new traffic.

PART II.

Social questions.

I. —General considerations.

In the foregoing part of this report it has been shewn that the scientific organisation of work has had the effect of improving the working conditions of the staff.

Independently of these questions, however, and the advanced efforts made to make the work of all grades of staff less irksome and increasingly interesting, the railways have also interested themselves in the development of any measures designed to improve the all-round conditions of life of their employees. In this connection they have adopted a whole series of measures, some of which relate purely to the administrative side, whereas other are not confined to working conditions and shew that the Administrations consider it their duty to assist their collaborators even outside the actual scope of the employment.

This tendency is extremely interesting, as it appears to us to be a step in the direction of true social progress characterised by the reciprocal confidence and collaboration of employers and employees in the accomplishment of a common task.

As we have already pointed out, present circumstances have prevented certain railways from giving details of what they have done in this direction. We know, however, either from previous communications or by reports from outside, that they are not uninterested in these questions, and that they share our opinion that these measures are of prime importance especially during difficult periods.

This point of view is brought out in all three of the reports submitted on Question X.

Messrs. Soulez and Bloch have shewn that, if efficiency is to be maintained, the railways must have reliable employees at their disposal, who are eager to work well and also desirous of improving the service.

Messrs. Tosti and Valeri have stated that « Administrations should be recommended to develop amongst their men a more delicate sense of responsibility and devotion to duty. »

The same conviction has led Messrs. Mereutza and Panaitopol to advocate strongly that « Administrations should show the greatest interest in all that can maintain and improve the physical and moral health of the staff, in all that can improve their well-being, and in all that can remove their anxiety for the future, taking steps first of all to protect them from the dangers inherent to their trade ».

We will now examine the efforts made by the railways in connection with the above considerations, for which purpose it is proposed to extract the fundamental ideas which have induced railways to endeavour to increase the security, confidence and well-being of their staff.

II. — Conditions of remuneration.

The general conditions of remuneration have given rise to lengthy considerations which have been guided in each case by local conditions, but which appear to us to have been based on the following principles :

1. — Ensurement of equitable remuneration for all grades of railway employees. In fixing this remuneration it appears to us that it has not been overlooked that « the railway service can, with good reason, be considered as the most important public service of the nation, even in the face of the rapid development of other, more modern, means of transport (1), and this is not a mere assertion as the number of applications for employment received by the railways, at least in the countries with which we are most familiar, shews that the railway staff is in a position which is far from being inferior to that of workmen engaged on similar tasks in other branches of industry, both as regards difficulty and the amount of effort exerted.

We have noticed that in numerous countries the wages are not fixed by the administration alone, but arrived at after

(1) Report of Messrs. Tosti and Valeri.

unfettered negotiation between the administration and the staff representatives, and also, that permanent contact is maintained so as to leave the door open for examination of any modifications which may be called for owing to pressure of economic conditions.

2. — Encouragement of the staff to be efficient by establishing conditions of promotion and premiums for production or regularity of work designed to reward good service, and, on the opposite side, the penalising of negligence and bad workmanship.

We consider that something can usefully be said at this juncture about the question of premiums, regarding which the 1930 Congress did not express an opinion.

The premiums granted by those railways which replied to the reporters are in two distinct categories : one being immediate recognition of the quality and quantity of the work done, whereas the others are proportionate to the general effficiency of the system, i. e., its profits, and to the part played by each towards achieving the results obtained. We will examine these two categories separately.

a) *Premiums for work.* — The granting of premiums is the natural outcome of scientifc organisation in the workshops, yards and offices. After a workshop or yard (using the terms in their most general sense) has been scientifically organised and the operations performed therein analysed and timed so as to avoid loss of time and overlapping, it still remains to ensure, by the goodwill and education of the staff, that each operation is carried out in less time than that first ascertained, which can only be considered as an average.

This is the first type of work premium, designed to give the staff an interest in saving time.

Scientific organisation also takes account, however, of the quantity of material (this word likewise being used in its broadest sense including, for instance, electric power) used in effecting each single operation. In addition to saving time, it is therefore reasonable that employees should be given an interest in saving material.

This is the second type of work premium, i. e., for economy in material.

In the scientific organisation of a workshop or yard, after having ascertained the duration of each unit of work, it is necessary to ascertain the average time taken for the operation as a whole.

The saving on the total operation can only be realised by the good will of the men and the co-ordination of their individual efforts in performing the component operations, thus giving us a third type of work premium; viz., a premium for the general efficiency, to be shared between all the employes engaged, proportional to the part played by each.

These three types of premiums must be calculated on a mathematical basis wherever possible and comply in every respect with the following requirements:

The premium must in the first place constitute an exact measure or appreciation of the *individual efficiency* or merit of each employee to which it is awarded.

The method of determining each premium must be simple enough to be understood by all the employees concerned, so as to enable them to appreciate in what measure they may benefit by the result of their efforts and the greater efficiency which it has been possible to achieve by their good will.

Finally, the operation of each premium system must be rapid so that those concerned can be apprised of the awards as quickly as possible, and know immediately what the results of their efforts have been ;

b) *Premiums for the general efficiency of the railway.* — This kind of premium, which has been introduced by a certain number of administrations, appears to be

capable of a great deal of improvement yet, compared with what is being done at present. The difficulty is, as has been well explained by Messrs. Tosti and Valeri, that the special circumstances of the railway industry are frequently such as to make it difficult at times to determine to what extent each employee or group of employees has contributed to the improved working of the railway. Hence it is that general premiums, when applied, are not actually a true participation in the profits, but rather a bonus, varying for each person according to the quality of the individual work performed and varying for all concerned according to the financial results, obtained by the railway.

It may transpire, however, that the improved methods of railway working which are now being evolved will make it possible for the formulæ in operation in certain countries to be made more precise.

Messrs. Mereutza and Panaitopol after having described how wages are thus made up — at least for certain grades of work — of a fixed portion according to the nature of the work, supplemented by a premium varying with the quality of the work, point out that the ratio of the premium to the wage varies for each type of work, the premium diminishing in proportion as the direct influence which the work has on the general efficiency of the railway becomes less.

3. — Improvement of the employees' family life by the granting of various kinds of family allowances. These various kinds of allowances are for the purpose of reducing the difference between the material positions of two employees holding posts at similar rates of pay but one of whom is married and the other single. Being animated by the broadest conception of mutual well-being, the railways have thus endeavoured to assist parentage and encourage the family spirit.

4. — Ensurement of the material security of railway employees by granting pensions to old servants on retirement.

The amount of such pensions varies considerably according to local conditions. In the majority of cases, pension funds are made up of payments by the employees and the railway, but it will be appreciated that the individual arrangements are conditioned by numerous factors which vary with each particular case. The level of remuneration, the existence of state insurance, morals, habits and local requirements are all factors to be taken into consideration by each railway in the organisation of its pension system.

5. — Granting of special facilities to the employees for utilising the means of transport which they operate, such facilities constituting a sort of « payment in kind » as well as a concession much appreciated by the staff.

III. — **Social work.**

1. *General considerations.* — In addition to the foregoing the railways have turned their attention to measures known under the general title of « Social Work », which, while falling outside the scope of the employment itself, are aimed at increasing the comfort and security and improving the material conditions of life of the employees and their families.

Although, as has already been stated, these efforts are inspired by a high and disinterested sense of social responsibility they have this advantage for the railway that they increase the regard of the staff and tighten up the natural interdependence between collaborators engaged on a collective task.

The measures taken in this direction have various objects, such as the improvement of housing conditions, medical, pharmaceutical and dental attention, hygiene, education of children, various récreations, purchase of commodities and

provisions, etc., and also assistance to employees temporarily incapacitated or ill, widows or orphans, and the finding of suitable employment for the latter.

2. *Housing.* — As regards housing, the railways have made very great efforts during the recent period of general house shortage. These efforts have been aimed in various directions according to local conditions, but are based essentially on two principles :

a) Construction of houses by the railways themselves for the use of the employees and their families, at low rents;

b) Pecuniary or other facilities extended by the railways to staff desirous of owning their own dwellings.

The needs provided for by these two methods are not the same. The first is designed to enable the staff to find healthy living accommodation near their work. The railway therefore builds a house which may be isolated (e. g., a level crossing keeper's house) or grouped with others (railway town), but the use of such houses is only allowed to staff performing certain definite duties, e. g., level crossing keepers, marshalling yard employees, etc., and only for the duration of those duties. Men who leave, either owing to retirement or transfer to another position, must surrender the house to their successors.

Contrariwise, under the second method, men desirous of setting permanently in the locality of their work are given special facilities to acquire a house which will still be theirs after transfer or retirement, and which they can leave to their children.

In this case the railway does not itself build the house, but assists indirectly in a number of ways such as the grant of pecuniary assistance through co-operative building societies, advances at very low rates to persons building their own house, assistance to men wishing to avail themselves of State schemes, etc. All these measures have the common characteristic that they aim at making the house the private property of the employee.

The different objects pursued by these two methods respectively explain why the majority of railways who have informed us of their practice in this respect use both of them, endeavouring simultaneously to facilitate the temporary housing of their operating, etc., grades (immediate assistance) and acquisition by those desirous of owning their own dwelling, (partial or deferred assistance from the men's individual point of view).

The efforts put forth in one or the other of these directions have been on a very extensive scale both in European and non-European countries. In new countries, the question of housing the employees has in some cases assumed such importance that very few of the staff are not housed by the railway.

As already stated, the houses built for railway staff are often grouped into « towns » and this concentration has been particularly favourable to the development of ancillary facilities, such « towns » being generally provided with elementary schools, domestic science, or special schools, dispensaries, maternity centres, sports grounds or playgrounds, entertainment halls, swimming baths, etc.

Naturally, the inhabitants having these facilities at their disposal free of charge, or nearly so, find themselves in remarkably hygenic conditions, and the statistics furnished shew conclusively the beneficial effects which these efforts have had on the health of the community and the growth of population, the death rate being lower among the railway staff than among the ordinary population living in the surrounding districts.

3. *Medical assistance and pharmaceutical supplies.* — Irrespective of whether « towns » have been built or not, practically all railway administrations now

have an organised medical service. Provision is also made for pharmaceutical supplies, dispensaries, maternity centres, hospitals, sanatoriums, the railway either creating such institutions itself or procuring facilities for the staff to have recourse to external institutions.

In order to provide their staff with the possibility, should the need arise, of availing themselves easily of the most up-to-date therapeutical treatment, certain administrations have established laboratories and dispensaries at a number of fixed points, some railways possessing travelling clinics to meet the needs of employees, and even their families, living at a distance from the large centres.

All these measures are not merely for the purpose of examining the health of new employees, or maintaining the physical conditions of the staff in the active services, they also afford valuable assistance to the men's families in the fight against disease, most remarkable results having been obtained in respect of the discovery and cure of tuberculosis.

If, as a general principle, the railways have occupied themselves with these questions, the methods adopted are very diverse, for here again, as in the case of retirements, the local laws and in particular the conditions relating to State insurances have a very great influence on what is done by the railways.

Many of the administrations make a point of doing whatever they can to collaborate in the fight against disease, tuberculosis in particular, by giving their employees the opportunity of living in a sanatorium during the period of treatment and by sometimes making a benevolent allowance to the family deprived of its head, either temporarily or permanently, should death ensue.

Very considerable efforts have also been exerted in the fight against syphilis.

4. *Supply of foodstuffs.* — Special attention is drawn in the reports to the fact that numerous railways have endeavoured to assist their staff by enabling them and their families to obtain commodities at reduced prices. The methods adopted vary according to local conditions, but generally speaking they fall within the two following categories : Organisation by the railway itself of a « stores », i. e., an organisation which purchases wholesale food and articles of primary necessity and sells them to the staff without profit. The other procedure consists in creating co-operative societies which are self-contained and are managed by the staff itself. Numerous also are the railways that give material and moral support to these societies at a cost which may be comparable with that of running a stores, the view being held that the management of these societies has a valuable educative effect on the staff.

Certain administrations have adopted both methods simultaneously for the development of these facilities, which appear to have been particularly appreciated by the staff during recent years.

5. *Moral and mental development, recreations, sports, etc.* — In addition to material assistance, the railway administrations have interested themselves in the intellectual and social life of their employees by encouraging them to take part in wholesome recreation for the development of their intelligence, appreciation of art and so forth, the « towns » built for railway employees being thus endowed with theatres, cinemas, sports and playgrounds, libraries, etc.

Some railways publish a magazine which may deal with various matters but the chief object of which is to interest the staff in questions of railway operation, and to convey to them in a convenient form the reasons for the regulations which they have to observe and the duties which they have to perform in

the course of their career, the discipline necessary to the satisfactory working of the system being thus strengthened by understanding and confidence on the part of the men. The writing of the articles published in the magazine, moreover, provides, for those responsible therefor, an exercice as interesting and helpful to them as the reading of the articles themselves may prove for the lower grades. The authors must necessarily put themselves in the men's position and hence endeavour to understand them, and the analysis of railway life which has to be made for this purpose is of great utility in the establishment of regulations and principles, constantly requiring to be simplified and improved.

The reports stress the fact that the railway administrations have to some extent everywhere endeavoured to assist and encourage morally and financially the associations formed by the employees themselves in connection with sports or art : athletic associations, musical societies, etc. The social role played by these associations appears to us to be a very wide one, firstly for the development of professional solidarity between the employees of a railway company, by giving them the opportunity of associating and meeting one another outside business hours, and secondly, from the international point of view, by facilitating party journeys of employees outside their own system and even their own country on such occasions as sports meetings, for instance. These endeavours therefore have a very important « human » interest by reason of the bonds which they create or strengthen between the employees of a particular railway or of different railways and countries.

The various measures designed to provide facilities for the association and recreation of the staff outside business hours have been particularly developed by the British, French, German, etc., railways. The Italian State Railways, under the expressive term « Dopolavoro » (After work) have created an association which embraces almost the entire staff of 150 000 employees, and occupies itself both with the material needs of the employees' families and with various social activities, the scope of which extends outside business hours, as the title indicates.

IV. — Other measures adopted for the benefit of the staff.

1. *Holidays.* — The railway administrations have considered that it is not sufficient to limit the working period of their employees to a part of each period of 24 hours, but that it is further necessary to allow them a certain number of whole free days in which to devote themselves to family or personal affairs, or to rest and recreation.

Generally speaking, railway employees enjoy a weekly or periodical rest equivalent to the Sunday rest of the administrative and clerical services, but falling on a day determined by rotation in the traffic, etc., services continuously in operation.

In addition, the majority of the administrations deem it advisable to go beyond this and give their staff a certain number of consecutive days of complete liberty, hence the annual holiday in force on nearly all railways, during which the employee generally receives full pay or nearly so.

The moral and social effect of the annual holiday is obvious, and from this aspect the application of the principle seems desirable. The cost to the railways is of course a heavy one, and is only offset to a very limited degree by the increased efficiency due to the renewed energy derived from a wisely-spent holiday.

The need for periodical relaxation appears, moreover, to increase with the importance of the post held by the employee and the extent of his responsibi-

lities. Age would also appear to be a factor, young employees seeming to have need of a less long annual holiday than the older men.

Railway systems generally take the first factor into account in determining the length of the holiday, but the German Railways in their reply state that they also allow for the second, considering it necessary to vary the holiday period according to the age of the employee.

For certain railways which are outside Europe but employ European staff, the length and cost of the journey home make it more convenient for the holiday to be at longer intervals and therefore of longer duration.

2. *Prevention of accidents.* — The railway administrations have also elaborated a whole series of mesures dealing with the improvement of the conditions under which the work is effected. The reports show that all railways give their first attention to the safety of their staff and follow the question of accidents very closely, particularly in the direction of keeping the employees alive to the possibly dangerous consequences of their own mistakes. In many cases it has been considered desirable to set up a special committee to investigate cases of accidents in order to ascertain their exact cause and to prevent « systematic » accidents.

The developments to which consideration of the prevention of accidents has given rise have, as has already been stated, shewn the importance presented by the organisation of work from this point of view.

The railways have recognised that the most effective means of minimising accidents is to use good material and a staff well instructed in, and adapted to its tasks. This among other reasons has led several administrations to introduce the psycho-technical examination of candidates, while others are considering the possibilty of introducing such an examination, which is calculated to ensure not only that the employee is physically fit for this work, but to afford a further protection against possible accidents.

This question is so extensive as to merit special examination, perhaps, at some future date.

It is furthermore considered unnecessary to refer here to questions of professional instruction, which appear to have been dealt with very thoroughly in connection with question XVI at the Madrid Congress.

3. *Co-operation of the staff.* — Railway administrations have considered, too, that when local circumstances permit, they should appeal for the co-operation of their staff in perfecting the methods of work, and improving the conditions under which it is performed. The series of measures which we have enumerated and which tend to win the loyalty and regard of the employees thus find their consummation in a wholly desirable co-operation which, when local conditions lend themselves thereto, enable permanent contact to be maintained between the staff and their employers, thereby strengthening the reciprocal feeling of esteem and confidence which unites collaborators in a common task.

The measures adopted in this connection are essentially of two different categories :

a) Institution of staff representatives who are officially qualified to convey to the various railway officers any desires which the employees may wish to express in regard to remuneration, holidays, travelling facilities, or even the conditions of work. On a number of systems these same representatives are present in an advisory capacity when disciplinary action is being considered in cases of misconduct ;

b) Examination of any suggestions and ideas which the employees of all categories may submit for the improvement of the service. These suggestions

are collected and carefully considered. In some cases they are specially stimulated by the administrations, who may thus be led to the introduction of valuable innovations for the improvement of working conditions.

The view is held, withal, that even the suggestions submitted and not adopted are of value by the mere fact that they have been made, which indicates that the employee has interested himself in his work, has studied the methods employed and attempted to devise better ones, and awards are hence frequently granted either in the form of money or promotion to employees thus shewing initiative.

Summary.

Having analysed into what we think are their essential elements the three reports which we had to examine, we have now to extract the broad principle for submission to the Congress. It should be observed that the conclusions of these three reports, if not analogous, are at least very much akin on the whole. The special reporters submit to the 1933 Congress the following recommendations which are likewise based on the same views :

1. At the base of rail transport organisation is the general organisation of all means of transport, but to enable each to cater for its own traffic, the legal and fiscal obligations should be the same for all carriers.

This condition being fulfilled, the harmonious co-ordination desired must be sought for from the outside by effecting all possible connections between rail and other means of transport (road motors, mechanised inland water transport, aeroplanes) and also be pursued internally in each service, system and group of systems, in order to increase efficiency. It should be noted, however, that amalgamation, to which in certain cases co-ordination may lead, is limited, both as regards management and actual operation, by various circumstances.

2. The results which it is hoped to achieve from organisation not being entirely dependent upon the railways themselves, it is necessary, if the efforts made are to have really satisfactory results, that the administrative obligations to which the railways are subjected and the regulations by which they are goerned should be properly adapted to the existing economic conditions and the increased technical possibilities of new appliances.

The aim of modern organisation, as we conceive it, should be to carry out all mechanical work by machinery, leaving to the human being those tasks which require initiative and discernment.

Such organisation increases the safety of the employees, both by the abolition of certain work involving special risk, and by the introduction of devices which safeguard the operatives against the consequences of human fallibility.

Finally, the organisation of work together with the award of output premiums or shares in the general profits of the enterprise makes it possible to assure an increased remuneration to the staff.

4. The duties of controlling offices must be clearly defined and be simplified as much as possible, with a maximum of direct contact between each other and between them and the services under their direction so as to expedite to the utmost all matters dealt with.

A means of ensuring inter-service contact which we think can be recommended is the holding of periodical meetings between officials responsible each of part of a common task.

5. The operative services should be enabled to collaborate in the endeavour to discover more economical and reliable methods. In view of the satisfactory results already obtained in this connection, it would be desirable to extend

standardisation of stock as far as possible, reducing the number of types and standardising parts and the tolerances allowed therefor.

The various workshops and establishments should be organised on the same lines, adopting the principle of responsible specialisation, whilst not curbing the initiative of the staff. The organisation of work presents a similar aspect for all railway systems, and it might be of value for the railways to interest themselves in the work of the national and international bodies in connection with scientific organisation.

In this respect it appears to us that the improvements to be effected should consist, in the first place, in the simplification of the operations themselves, and secondly by the improvement of the plant. Finally, a prime factor to be kept in mind for the efficient organisation of work is the employment of staff physically fit to perform their allotted duties, and it is for this reason that attention is drawn to the development of the psycho-technical examination already introduced by a certain number of administrations.

6. The preceding measures concerning the material conditions of the organisation and preparation of work, appear to require the addition of a moral factor in the shape of the confident collaboration of the staff bringing with it a spontaneous display of collective goodwill, based on reciprocal esteem and equitable remuneration according to the efforts exerted and the results obtained.

It is considered that for determining this remuneration, the premium system, already made use of, should be developed. Under this system, payment consists of two elements : one fixed, and the other varying with the quality and quantity of the work done.

The premium should first be introduced at the base, that is for the elementary operations, and be so applied as to remunerate speedily the efforts of each employee and in particular the economies realised in regard to time taken and material consumed and the general efficiency of each establishment.

7. As brought out in the summaries adopted by the Congress in 1930, in connection with Question XVI on its agenda, it is necessary for railway employees to be well versed in their profession and also to have a good general knowledge.

Technical schools and educational schemes of all kinds instituted by the Railways for the instruction of their employees are therefore of first class utility for the improvement of the railways, and their importance cannot be overestimated.

8. For increasing the feeling of confidence and the security of the staff it is desirable that social and welfare work should be extended.

These measures, which are outside the scope of the actual employment, are aimed at maintaining the physical well-being of the employee and his family and assisting their material existence right down to the smallest detail. They result in the staff being more devoted to their work, more relieved of daily cares, and can therefore in our view be recommended as highly conducive to the attainment of improved efficiency of the railway systems.

QUESTION XI:

Competition between or joint working of railways and airways, or railways and roadways.

An investigation from the technical, commercial and contractual points of view.

By E. C. COX, C. B. E., M. V. O.,
Special Reporter.

The object of the present report is to summarise the two reports submitted on this question :

Report No. 1 (America, Great Britain, Dominions and Colonies, China and Japan), by Mr. E. C. Cox, Traffic Manager, Southern Railway of England (1).

Report No. 2 (All other Countries), by Messrs. Villamil, Chef de la Direction Commerciale du Chemin de fer du Nord de l'Espagne, and d'Ocon Cortes, Ingénieur au Service Commercial du Chemin de fer Madrid-Saragosse-Alicante (2).

Railways and roadways.
Extent of road competition.

The rapid and far reaching growth of road motor competition for the carriage of passengers and goods is outlined in each of the reports. In various countries and in respect of various railway administrations estimates have been made of the losses directly attributable to this competition but, generally speaking, it is difficult, if not impossible to give any precise figure for such losses due to the many varying factors and above all to the fact that at the present time the whole transport industry is affected gravely by the world wide trade depression. At the same time it is evident that only a portion, although a large one, of the passenger and freight traffic now carried by road motors has been lost to the railway systems as the total volume of movement, both of passengers and goods, is ever-growing and thus a part of the traffic carried by road is « new ». It is, in fact, easy to show that the development of road motors has brought certain traffics of quite considerable dimensions to the railway. On the whole, however, the railway systems of the world have sustained severe losses due to road motor competition and more particularly is this the case in the older more densely populated and highly industrialised countries. In the case of freight transport it is apparent that a country having great seaports, industrial and commercial cities, situate in close proximity and inter-connected by an excellent road system, offers an excellent field for exploitation of road motor services.

The railway systems of the eastern portion of the United States, of Great Britain, Germany, France, Denmark and Sweden, for example, have all to meet road competition in acute form.

Inequality of conditions.

The railway systems in all countries have been greatly hampered in their efforts to retain and increase their traffics by the inequality of the conditions applying to road and rail transport. From their inception, railways have been surrounded by a great deal of legislation as to safety precautions, conditions of carriage, powers of charging and publication of rates and fares. Such legislation has originated from the thesis that

(1) See *Bulletin of the Railway Congress*, May 1932, p. 729.

(2) See *Bulletin of the Railway Congress*, November 1932, p. 2113.

the railways enjoyed virtual monopoly and that the public had, therefore, to be protected in various ways.

On the whole the youthful road motor industry — which has completely altered the so-called monopoly position of the railways — has remained free from legislative entanglements. Undoubtedly, however, the main advantage which has been enjoyed by the road transport industry in all countries is that it has not had to bear its full share of the charges and responsibilities which should properly fall upon it.

Financial effects of competition.

Despite the strenuous efforts of the railway systems the losses sustained have been so heavy as to attract national attention in many countries. In some European countries, as well as in certain of the British Dominions and Colonies, the railways are State-owned and any losses sustained by the railway systems fall upon the National Exchequer and obviously involve additional taxation, while in countries not so situated, such as Great Britain and the United States, the railway systems are so vast that impoverishment of the railway industry could not fail but to have severe repercussions on the economic prosperity of the nation.

The reports show that it is beginning to be realised by the public that unregulated competition in surface transport is wasteful in the extreme and causes economic loss and, further, that the cheapness of some forms of road transport is more apparent than real because the vast cost of the highways is not borne equitably by the user but is transferred to the community, in other words, that the road transport industry is subsidised by the rate and taxpayers.

Legislation concerning road transport.

It is impossible within the scope of this brief report to deal comprehensively with the legislation which has been, or is being, introduced in the various countries and is designed to confer a measure of equality on the two forms of transport and, above all, to safeguard national economic prosperity.

A perusal to the reports will show, however, what such legislation generally seeks to secure :

a) A road service can only be operated by licence and the licencing authorities are to have regard in determining whether a licence should be granted to the suitability of the route, the extent to which the route is already served, the needs of the public and the co-ordination of all forms of transport *including transport by rail;*

b) The suitability of the applicant, the use of vehicles which are in a state of mechanical efficiency and the observance of certain hours and conditions of labour;

c) That the cost of maintaining the highways is borne by the users and is equitably shared by the various classes of users.

Legislation introducing a licencing system is in operation in Great Britain in so far as passenger transport is concerned and in several of the British Dominions, in Germany, Belgium and other countries while, with regard to the third consideration — the bearing of the cost of highway maintenance — this is dealt with in several ways, but mainly either by increasing the direct taxation on road motor vehicles or their fuel, or by causing the operators to contribute a portion of their receipts to a road fund or the National Exchequer.

An examination of the two reports will show how various countries have introduced legislation designed to secure this object, or have proposals for such legislation under consideration. At this juncture it may be remarked that while passenger road transport lends itself easily to a licencing system, this does

not apply to freight transport particularly owing to the fact that a large number of road motor freight vehicles are not plying for reward but are carrying goods forming the property of the owner of the vehicle and it seems probable, therefore, that in the main freight vehicles will have to be subject to increased taxation rather than regulation by a licencing system. Such vehicles should, however, require to be examined as to mechanical efficiency and the question of suitability of drivers and conditions of labour needs consideration.

Co-ordination of transport.

The railway systems have everywhere essayed to co-ordinate the two forms of transport. In countries such as Great Britain, where the railway companies did not possess general powers to operate road services, such powers have now been secured. In general it can be said that either by means of road transport services operated directly by the railways or by alliances with road operators, the railway systems have sought to co-ordinate the two services so that :

a) The one becomes a feeder to the other, particularly in the case of passenger transport;

b) Door to door transport of merchandise is given by the provision of adequate collection and delivery services.

Means of combating road transport.

The railway systems have given much thought to such means as lie within their powers to improve their facilities and the following headings give an idea of the lines on which progress has been made :

Passenger traffic.

a) Electrification of lines carrying large and constant traffics as in the case of the Southern Railway suburban services. Electrification, assisted by modern signalling enables frequent, rapid and punctual services to be given;

b) Provision of steam, oil or petrol driven rail coaches in substitution of branch line steam trains on lines carrying comparatively light passenger traffics. This is a method which has been adopted with a considerable degree of success in France, Belgium, Czechoslovakia and Spain, for example;

c) A general overhaul of timetables with a view to the speeding up of services and the provision of convenient connections;

d) Reductions in fares and provision of special cheap fare facilities where the circumstances justify such a course.

Goods traffic.

a) Reduction of rates;

b) The provision of containers so avoiding packing, reducing handling and in co-operation with collection and delivery services, giving door to door transport. The rapid progress made on these lines in Great Britain and the United States is shown in report No. 1, but it will be noticed that the authors of report No. 2 do not consider the container in quite such a favourable light;

c) Affording door to door services by means of cartage at one or both terminals. The British Railways have always provided a more or less comprehensive collection and delivery service contrary to the usual European and American practice. The European and American systems are now providing such services themselves or making suitable co-operative arrangements with local carriers or large « Express » companies;

d) Provision of warehouse and storage facilities for traders in railway goods yards;

e) Provision of express freight trains and the expedition of transport by partial use of motor transport;

f) Provision of special vehicles, such as milk tanks, road rail tanks, etc. for special commodities.

General conclusions.

From a railway and indeed from a national standpoint it is of the greatest interest to note from the reports that all over the world public opinion is coming to the conclusion that inequitable, unregulated and wasteful competition, besides causing grave loss to the railway systems, is not in the public interest and that as a result in one form or another regulation and co-ordination of the two means of surface transport by land is beginning to take place and ultimately there seems little doubt that a rationalised system of transport enabling each service to play its part to the full will be achieved.

The railway systems, however, must not content themselves with their present state but must make every effort to provide cheap and more efficient services and so justify their positions as the prime carriers by land.

Railways and airways.

An examination of the data contained in the two reports shows that airway competition with railways is of an entirely different character to that of road motor competition. The essential advantage of aircraft is great speed — in actual flight from two to three times that of the fastest express trains — and, whereas road motor services flourish where the centres of population are grouped closely together, the airway shows the greatest advantage when linking up large centres far apart from one another, such as New York and Chicago, New York and the Pacific Seaboard, London and Paris, Berlin and the East. Broadly speaking the greater the length of route to be covered the gerater is the amount of time saved by airways as compared with surface travel.

Airways also enable direct services to be operated between places which are not, and in many cases cannot be, easily or rapidly connected by land or sea transport and in some such cases the time occupied by the air route is but a fraction of that required by other means. Examples of this are to be found in the airway services provided by Imperial Airways connecting London and Persia, Iraq, Kenya, Uganda, Rhodesia and the Cape. Other examples are given in the reports.

The cost of providing and lighting aerodromes and airway routes and equipping and operating suitable aircraft is very high and, as the reports show, most of the present airway services are subsidised directly by the State or receive special payments for the carriage of mails, so that in general airways do not compete, if such it can be called, on an equal economic basis with the railways.

On the whole the total volume of traffic carried by airways is small and probably it has very little effect on railway receipts, while in certain parts of the world the opening up of districts by airways has brought increased traffic to the railway system.

The reports show the great railway systems in Europe and America are fully alive to the possibilities of air transport and have already secured a large measure of co-ordination between the two services. Undoubtedly many improvements will take place in the construction of aircraft but at the same time still further progress will be made towards such a co-ordination of services as will enable each service to take its proper part in a rationalised transport system which will be to the benefit of the industries concerned, the users and the State.

SECTION V. — Light Railways and Colonial Railways.

[625. 61 (0]

QUESTION XII :

Co-ordination of operation as between heavy and light railways,

by L. JACOBS,

Special Reporter.

This question was dealt with in two reports : Report No. 2 covers all countries except those of the Continent of Europe, and was prepared by Mohammed Sobhi Ishak Effendi, Inspector and Secretary of the Egyptian Light Railway Commission (1). Report No. 1 deals with Continental Europe and its author is the Special Reporter (2).

The scantiness of the replies to the questionnaire and the very diversity of the conditions revealed by these replies made the preparation of Report No. 2 particularly difficult and did not permit of the formulation of any general conclusions.

The fourteen replies received issued in part from companies grouping the two classes of railway under a single administration : this is the case with the railways of South Africa, of the Niger, of Morocco, of French West Africa, of Algeria (P. L. M.), of Ceylon, of the Dutch East Indies; also with the Great Indian Peninsula Railway, the Buenos Ayres Great Southern Railway and with the railways of New South Wales. On the other hand, there is supervision exercised by the Government in the case of the English Railways, the County Donegal (Ireland) Railways, the Egyptian Railways and the Corean Railways. In no case are there completely independent organisations, and it is precisely in the case of such organisations that the efforts and achievements in the direction of co-ordination would have been the most interesting.

The Reporter has succeeded in bringing together under two headings the different data placed at his disposal. The first chapter of Report No. 2 is devoted to the construction of *light railways and their rolling stock.*

After having pointed out the diversity of the conditions governing the construction of light railway systems and their co-ordination with the main railway system, the Reporter briefly examines the variety of work assigned to light railways; the financial, commercial, political or strategic reasons which usually make the choice of gauge, usually narrow ; the inconvenience which sometimes results from the adoption of a narrow gauge; the absence of competition between the two railway systems in Egypt, where the lines run transversely. Finally, the Reporter remarks that interchange of rolling stock is only possible between railways of the same gauge, and then only provided the structures and the permanent way are sufficiently strong. He further remarks that light railways are in general equipped with a view to affording the same transport facilities as the main railways.

Chapter II (Operation, Rates), points out in the first place the absence in the majority of cases of a fixed maximum period for the transport of goods.

As regards rates, it underlines the two systems, viz. mutual agreement between the railways themselves, and government intervention. As there is general-

(1) See *Bulletin of the Railway Congress*, September 1932, p. 1793.

(2) See *Bulletin of the Railway Congress*, May 1932, p. 775.

ly no competition between the two railway systems, no steps have been taken to prevent the diversion of traffic from the main railway; elsewhere (Great Indian Peninsula and Egyptian Railways) minimum rates are in force or, alternatively, the traffic is proportionally divided. The Reporter then examines the question of the insurance of goods, the fixing and collecting of carriage and station charges. He remarks that for railways with different gauges there are joint stations with a common transhipping bank, or again with direct transhipment from wagon to wagon on parallel tracks.

Finally, the light railways have declared that they were authorised, in the same way as the main railways, to inaugurate motor-bus services. England and Egypt grant this privelege only to the main railways. On the Algerian lines of the Paris-Lyons-Mediterranean Railway, motor services are placed in the hands of third parties and have their own rates.

* * *

Report No. 1 on Question XII, which I have had the honour of presenting to the Congress, examines the co-ordination of main railways and light railways in Continental Europe : out of 131 administrations consulted, 86 have not replied and 13 have replied that they had nothing to say. Out of the 32 replies received, 12 emanated from light railways. The Report which we have been able to prepare from the material thus made available is subdivided as follows : In what co-ordination consists — exchange of goods — exchange of passengers — new methods of transport, new means of co-ordination — administrative relations between railways — general remarks and summary.

Co-ordination has served as the pretext for so many financial or political experiments that it was necessary to arrive at a precise definition of its meaning before proceeding to examine its methods and results.

To co-ordinate is not to amalgamate, nor to subordinate, nor to annihilate.

The co-ordination of transport facilities consists in the application of elementary economic principles and will only be found to occur under the pressure of facts. These facts are : the freedom of motor services to develop haphazardly, whence parasitism to the detriment of the general public interest and losses for the public services which have been established at great capital investment, and further, in many cases, losses for the public finances which are heavily involved; the multiplication of separate services competing for the same business and the consequent uneconomic immobilisation of capital; the inertia of governments, accentuated moreover by their post-war difficulties; finally, retarded railway evolution due to the same causes. To summarise : the general economic problem dominates the technical and financial aspect of co-ordination and must consider primarily social interests and the common welfare of a nation as a whole.

If co-ordination is suggested by considerations of general interest, it is the duty of Governments to see that it does take place. It follows : 1. that transport facilities must be adapted to the requirements of the country as a whole just as much as to immediate local requirements; 2. that transport charges must be kept as low as possible and that it is necessary to avoid the institution of a supplementary means of transport which puts up prices to the detriment of the general economic situation; 3. that the transport by rail of passengers at reduced fares is of considerable economic and social importance and that a form of competition which would deprive the railways of precisely those passengers who pay full tariff should not be tolerated, a con-

sideration which applies equally in the case of goods traffic; 4. it follows that the railways — which are factors of economic and social importance — must be safeguarded to the extent to which they are based on disinterested principles and serve the general economic interest; 5. it is therefore their duty to modernise themselves without waiting to be compelled to do so; 6. it is the duty of Governments to protect national — and not merely regional or local — interests; 7. the performance of this duty must not take the form of abusive or tyrannical interference, but of advice and supervision such as will tend to promote healthy co-ordination.

The urgency of co-ordination has not escaped the attention of the various Governments. Proof of this is to be found in the definite statements made : in France by the President, Mr. Laval, by Mr. Deligne, Minister of Public Works, and by the Prefect of the Seine Departement; in Great Britain, in the reports of the Ministry of Transport; in Germany, by Dr. Gutbrod, Secretary of State; in Belgium, by the Ministers of Transport, Messrs. Lippens and Van Isacker, as well as by the Belgian Prime Minister, Mr. Renkin.

All are agreed in recognising that a comprehensive solution of the transport problem is an urgent necessity, the more so as the cases of co-ordination which have been realised between main and light railways are only exceptional and, in any case, more apparent than real, as is shown by the replies to our inquiries. Let us briefly examine the results achieved.

I. — Exchange of goods.

This question has been neglected by the main railways, despite the desires expressed by the light railways. Our report cites numerous examples, however, which prove that it is not because traffic interchange is wanting. It is often sufficiently important to justify the provision of quite costly installations which, by diminishing expenses, should have the effect of increasing traffic at present discouraged by the high costs of handling. As a rule, the contributions demanded from the light railways for the use of installations such as overhead travelling cranes, cranes, weigh-bridges, etc., are too high. There have, however, been cases where an agreement, not of a one-sided nature, has been arrived at. In this connection we may refer to the Swiss Federal Railways, which have special installations for the interchange of loaded wagons between their lines and those of the narrow gauge railways. Similarly, cranes are placed at the disposal of the light railways or of the transhipping agents, partly without charge and partly at low charges.

It is equally desirable that duplication of installations should be eliminated as regards buildings, water cranes, tracks, rolling stock, wagons and engines or shunting tractors.

Why indeed should it be less easy to arrive at an equitable understanding between the main railways and the light railways than between the main railways themselves ? Examples to the contrary are, however, not lacking, and they also show how many book-keeping operations and other activities might be avoided, and how much saving could be effected under the heading of staff.

It is equally clear what a disastrous effect is exercised upon the development of traffic, and indeed upon its very conservation, by the exaggerated demands of certain railway companies, who consider they are following a clever business policy by demanding from the light railways excessive contributions for policing, sidings or transhipment charges, or for the renting of land and lines, or for the hire of rolling stock.

It is typical to note that the main railways consider it logical to place gra-

tuitously at the entire disposal of their competitor, the motor lorry, their goods stations and the installations appertaining thereto, and, further, to provide maintenance and policing, whereas they require the light railway to pay for everything, even within the area of the stations belonging to the main railways, as well as policing at level crossings.

All this is contrary to equity and in conflict with the most elementary economic principles. Undoubtedly the light railways suffer more from road competition than the main railways which facilitate it but, once the light railways have been ruined, the main railways will find themselves at grips with a single adversary whose hands they themselves have done their best to strengthen.

Our report describes several of the systems in operation, where it is easy to discern what corresponds to the general interest and to the interests of the railways concerned. For the rest, at a time when competition against the railways makes itself most felt on short distance routes, is it not rational to treat the light railway — which is the natural feeder of the main railway — as a prolongation of the latter, by organising interchange stations and by granting the light railway the right of « joint user » of the junction station with a view to reducing the cost to the users ? The utility of standard gauge transporter trucks, and still more for narrow gauge, which render possible an approximation to the system of transport by containers, is well-known.

The abolition of the railway monopoly being an accomplished fact, an alliance between the main railways and light railways is imperative, with a view to the elimination of all uneconomic competition, which can be achieved largely by an equitable sharing of the costs of joint installations, by the adoption of rates equivalent to those applied by competitors, and by the provision of services for the collection or delivery of goods at domicile, while continuing to exploit the possibilities peculiar to each of the two types of railway.

II. — Exchange of passengers.

It would be superfluous to repeat what might be done to save loss of time to passengers utilising successively a main railway and a light railway. The separation of the stations of the two systems, their nearness to each other and yet the absence of direct connection, prohibition of crossing the lines, termini far from the urban centres and railway stations imposed upon the suburban lines : all this acts to the detriment of the light railway and to the advantage of the motor-bus, and is directly contrary to the principle of co-ordination.

The main railways as a common case show no interest in the working requirements of the light railways and make scarcely any effort to co-ordinate timetables, to improve the conditions governing the interchange of parcels, farm produce and piece goods. The example set by the Swiss Federal Railways shows, however, how efficacious is the joint transport system, which benefits the passengers of the two types of railway, by issuing through tickets, by there being no enclosures, by the passengers being able to change trains from the same platform, or by using subways, or simply by crossing a station yard or building. In such a station special platforms are set aside for transhipping luggage, parcels, mail, etc. Everything possible is done to bring the light railway right into the station itself, thereby to facilitate interchange.

The same tendency is to be observed in the case of the French Nord Railway Company, which goes so far as allowing the light railways to run over certain stretches of its lines in order to reach either important towns or railway junctions.

As the public no longer limits itself, so far as the choice of the method of transport is concerned, to considerations of price, comfort and safety, but demands in addition both speed and frequency of trains, an intelligent appreciation of the mutual interests involved is alone capable of inspiring understandings between the different railway systems, involving possibly concessions and even sacrifices. To refer to another aspect, in proportion as the railway acquires new stock : (electric vehicles and light rail motor coaches) the interpenetration, and therefore the interdependence, of the different railway systems increases. It has been fully realised in a number of countries that co-ordination must be accompanied by modernisation : on the one hand main railways are being electrified to work the through services; on the other hand, on suburban and rural light railways, steam traction is being replaced by electric traction, by electric or internal combustion engined rail motor coaches, by trolley buses and even by motor buses.

The « Micheline », the « Pauline » and the « Road-Railer » are well known to everyone.

In Belgium, the National Light Railway Company, as the result of the successful experiments carried out with rail motor coaches, is building in its own workshops a rail motor coach, utilising the frame and body of an ordinary railway carriage. This rail motor coach will be moderate in cost and will provide seating accommodation for 26 passengers with standing room for 16. It has been described in our report. The Company is contemplating the construction of 250 vehicles of this type for use on lines where the small amount of passenger traffic no longer justifies steam traction.

It goes without saying that, just as much as the rail motor coach, the motor bus, an element of modernisation, constitutes a further obligation to co-ordinate.

III. — New methods of transport : new means of co-ordination.

A close understanding is essential between main and light railways, whether from the point of view of collaboration between rail and road, the one completing and prolonging the other, or from the point of view of the sharing of the respective equipment between given points with the object of affording the most economical, rapid and frequent transport facilities.

What has been achieved in this direction by the S. E. S. A. in Switzerland is well known. The first stage in this particular case of collaboration between railways was the adoption in 1927, for all goods traffic, of the same tariffs as those charged by motor transport enterprises, at the same time providing, as do those undertakings, for collection and delivery at domicile. The second step was the organisation of services for collecting and distributing goods in areas which are not served by a railway. The same tendency towards co-ordination exists in France, Germany, Italy and Holland, though in varying forms. It is obvious that in the long run ideas are improving and that the attitude which led the main line railways to under-estimate and neglect the collaboration of light railways in the common defense tends to disappear.

As regards motor bus services, however, it is evident that they cannot be allowed to constitute a duplication harmful to existing public services and to the general economic situation, although they may be justified in a supplementary capacity in districts adjoining others which already possess transport facilities, in certain cases as a substitute or for mixed service in conjunction with railways, or for increasing the frequency of services. It is very

desirable that the creation of new motor bus services should everywhere depend upon the authorisation of existing public services, as is the case in Germany where, since 1929, it is dependent upon the consent of the German State Railways and the Post Office.

It is of the greatest importance that in each country an organisation common to the two types of railway should be constituted with the mission of facilitating the relations between them and cutting out forms of competition imcompatible with the general interest.

IV. — Administrative relations between railways.

These relations, which are almost non-existent so far as practical co-ordination is concerned, might well be regulated by the higher transport authorities which have been constituted in a number of countries, if these authorities, realising that the former monopoly of the railways no longer exists, were composed exclusively of real experts and were in a position to take action under Government control.

Such transport authorities are even more necessary in most of the countries of Europe, where there are many areas which have excessive transport facilities relatively to the actual or potential traffic requirements, while other neglected areas require additional means of communication in order to foster their development.

It appears to us, therefore, that the essence of the problem of co-ordination is the adaptation of the means of transport to the nature and quantity of the traffic, due regard being paid to the general economic situation. There can, moreover, be no satisfactory co-ordination in practice unless the lines which such co-ordination is to follow are clearly defined in advance.

From what has been said certain conclusions may be formulated which, we are happy to note, coincide with those of the great rail and road Congresses of Madrid and Washington and with the resolutions passed by the International Chamber of Commerce at its session in Washington, in May 1931.

Everything points to the conclusion that it would not be logical to co-ordinate rail and road transport without previously co-ordinating the activities of the railways themselves. We do not think anyone will deny that considerable progress will have been made once the administrations of the railways, both main railways and light railways, are in agreement not only in regard to the necessity for co-ordination, but also in acknowledging the ideas of solidarity, interdependence and community of interests which must inspire all their efforts.

The first step in this direction seems to have been made. On the 30th June 1932, the Hague Congress of the International Union of Tramways, Light Railways and Public Motor Transport Services, after considering the report presented on the subject of Question XI, regarding comparison between different methods of rail and road transport, adopted conclusions the wording of which is inspired by the same principles as those set forth in the report which is now presented to you.

We may perhaps be allowed to add that the Reporter, Mr. Jourdain, has felt able to adopt the entire text of point 4 of our summary in substitution for his own text. This identity of views appears to us to be worthy of mention.

SUMMARY.

We have the honour to submit the following resolutions for the approval of the Congress :

1. The most essential principle which must govern all co-ordination, and in particular co-ordination between main

railways and light railways, is first of all the defence of the public interests, that is to say, the safeguarding of the public economy.

2. The interests of the railways should coincide with those of the public in general : this is the principal criterion for any sound railway co-ordination.

3. Public railway services — constituting an important part of the national equipment and fulfilling an economic and social function the benefits of which, mainly of an indirect nature, generally extend to the whole national community — have the right to protection against anything that tends to ruin their work, provided they endeavour to improve their operation and adapt themselves to the exigencies of traffic.

4. It is the duty of the central authorities to ensure that the transport policy is such that no undertaking likely to prejudice national economic interests can be started.

It is, therefore, their duty to prevent whatever might impede the modernisation and co-ordination of the main railways and light railways and, in particular, economically unjustifiable duplication of services and forms of competition which make profits for private interests at the expense of the general interest.

For the same reasons it is incumbent upon the Governments to take all possible steps to see that this co-ordination is accomplished, and in a manner conducive to the progress of the country as a whole.

September, 1932.

[621. 132.8 & 625. 616]

QUESTION XIII :

The use of rail motor cars on secondary railway lines,

by Enrico MELLINI,

Special Reporter.

Question XIII for the twelfth Session of the Railway Congress, concerning « the use of rail motor coaches on secondary railway lines » has been made the subject of three reports :

Report No. 1 (Great Britain, Dominions and Colonies, United States of America, China and Japan), by Mr. A. D. J. Forster, Assistant Railway Commissioner, New South Wales Government Railways, Sydney (1).

Report No. 2 (Continent of Europe [except Italy]), by Mr. Level, directeur de la Compagnie générale de voies ferrées d'intérêt local, Paris (2).

Report No. 3 (Italy and Colonies, Africa [British Dominions and Colonies excepted], Latin America), by Messrs. E. La Valle, directeur du bureau central du conseil technique près l'Inspectorat général des chemins de fer, tramways et automobiles, Rome, and E. Mellini, inspecteur supérieur de l'Inspectorat général des chemins de fer, tramways et automobiles, Rome (3).

The French and Italian reporters agreed the wording of a questionnaire which has been reproduced at the end of the report of Messrs. La Valle and Mellini. The English reporter had prepared a somewhat different text, which has been included in the appendices to his report. Each questionnaire was sent to the participating administrations in the countries covered by each individual report.

It must be observed, in the first place, that the reports Nos. 2 and 3 are drawn up on perfectly comparable lines, due in particular to the fact that, following the same questionnaire, a separation has been made between the strictly technical part of the reports and the part which is of general interest, concerning more particularly the influence that the use of rail motor coaches may exercise on the vitality of light railways. Report No. 1 has followed somewhat different lines, the questionnaire in this case being divided into five chapters, *viz.:* Organisation — Particulars of cars — Technical — Technical and economic results — General observations; the last chapter may be considered as a summary of the four preceding chapters and of the appended tables.

It may, however, be stated that the very slight differences in the method of examination of the question are more a matter of form than of substance and that, in reality, a comparison may well be made between the remarks relating to different countries, as well as between the opinions of the reporters on

(1) See *Bulletin of the Railway Congress*, April 1932, p. 451.

(2) See *Bulletin of the Railway Congress*, June 1932, p. 1133.

(3) See *Bulletin of the Railway Congress*, September 1932, p. 1801.

the subject of each question dealt with, all of which tends to simplify the work of the special reporter in formulating the summary for submission to the Congress.

1. Report of Mr. A. D. J. Forster.

The reporter says, in the first place, that the principal reason for the adoption of rail motor coaches has been their economic advantage; but the desire to improve transport facilities and to fight competition by road transport also plays an important part.

In North America the use of vehicles with a single driving compartment is practically general; it necessitates turning the vehicles at terminal points. In recent designs, however, there is an evident tendency towards the use of two driving compartments. In other countries, vehicles with two driving compartments are the rule. In no case has the multiple-unit control system been used.

The driving of steam rail motor coaches necessitates the employment of a fireman in addition to a driver, whereas the other types of motor coaches are operated by a driver alone.

Particulars of cars.

It may be said that in North America the petrol-electric vehicle is the normal type built in recent years; in other countries steam vehicles are more widely used.

In North America engines of 200 H. P. or more are in general use; in other countries engines of 100 H. P. are the rule.

In North America the vehicles of the usual types are very long [21.35 to 22.85 m. (70 to 75 feet)] and all metal construction is becoming more and more general; their tare weight varies from 45.4 t. (100 000 lb.) for vehicles of wood and metal construction, with a single engine, to 72.6 t. (160 000 lb.) for all-metal vehicles with two engines. The usual length of body in other countries is about 15.25 m. (50 feet) except for articulated vehicles; and the tare varies from 13.6 to 29.5 t. (30 000 to 65 000 lb.).

The number of pairs of wheels driven by the engine is generally one in the case of 100-H. P. engines; always two in the case of engines developing up to 300 H. P.; and four in the case of engines of 400 H. P. and upwards.

The Canadian National Railways have adopted articulated construction for their rail motor coach fitted with an eight-cylinder engine.

Power brakes are in general use; the vacuum brake is generally used for steam motor coaches and the compressed air brake for the other types.

Technical.

The steam motor coaches are Sentinel-Cammell or Clayton vehicles and the equipment is of the standard type produced by these firms. The boilers are coal-fired.

Internal combustion engines are of two types : spark ignition and compression ignition. The first type predominates.

In the majority of cases, with mechanical transmission the multiple type dry plate clutch is used. The gear boxes are generally of the sliding gear type.

The electric motors are of the nose supported tramway type, with cylindrical or helical gearing.

On the petrol-electric vehicles arrangements are provided frequently whereby either the main generator or the exciter can be used as a motor to start up the engine. In some cases compressed air starters are provided, or starter motors. On the petrol-electric vehicles starter motors supplemented by hand starting are the rule.

Technical and economic results.

The quantity of fuel carried by steam motor coaches suffices for a distance of

from 160 to 240 km. (100 to 150 miles); for internal combustion motor coaches the relative figures are 320 to 1 290 km. (200 to 800 miles).

The normal speeds are about 40 km. (25 miles) per hour.

The petrol consumption varies, according to the type of vehicle, from 1 to 3.5 km. per litre (2.76 to 10 miles per gallon); whilst the consumption of heavy oil is from 0.7 to 1.5 km. per litre (2 to 4.2 miles per gallon). As regards lubricating oil, a litre is sufficient for about 35 km. (100 miles per gallon).

In the case of North America, working costs may be apportioned as follows : fuel, 15.2 %; stores, 6.3 %; wages, 49.1 %; repairs 29.4 %. For other railways, the results are as follows : fuel, 31.2 % stores, 1.6 %; wages, 36.1 %; repairs 31.1 %.

General observations.

On the majority of railways the total costs of rail motor coaches vary between 22 and 31 cents per vehicle-kilometre (between 35 and 50 cents per vehicle-mile); for steam motor coaches the average expenditure is 44 cents per mile.

In general the railways which have been consulted express satisfaction with their present rolling stock.

The reporter concludes with the statement that working by means of rail motor coaches has been adopted, above all, because of the need for economies consequent upon the falling off in the traffic. If very few rail motor coaches are at present under construction, the primary reason must be sought in the difficult financial situation and not in lack of confidence on the part of the administrations.

The present tendency in the designing of rail motor coaches is towards the use of more powerful vehicles, which would seem to entail the adoption of electric transmission. This tendency, so far as steam motor coaches are concerned, would lead back directly to steam locomotion. We must therefore return to the internal combustion engine, where we have the choice between the explosion motor and the compression motor. Weight, price and lack of experience have up to the present militated against the extended use of this type. The future will show whether improvements in design and in the methods and materials of construction can remedy these drawbacks, and whether the advantage possessed by heavy oil, from the point of view of cost, will be maintained.

2. Report of Mr. F. Level.

The reporter states, in the first place, that at the present time the utility of rail motor coaches, as one of the elements of up-to-date working of light railways, is no longer contested by anyone. The satisfactory results achieved by their use are particularly apparent in a period of crisis which, more than ever before, makes economic working a vital question for all railways.

The report considers three categories of rail motor coach : light, heavy and special.

The first category comprises : *a*) rail motor coaches of the rail motor bus type, having a low tare weight, of not too high a price, affording accommodation for from 25 to 30 passengers, and with working expenses of from 1.046 to 1.50 French francs per km. (1.683 to 2.414 fr. per mile). This type of vehicle has not undergone any important modification; *b*) rail motor coaches of the railway type, of average power (45 to 110 H. P.), with working expenses varying from 1.40 fr. to 2.93 fr. per km. (2.25 to 4.72 fr. per mile). These rail motor coaches can also use Diesel engines, which are flexible, have a large

reserve of power, and are capable of high speeds under ordinary working conditions. The report indicates the necessity which exists at the present time of standardising, in several types, the different vehicles coming within this category, and considers the possibility of coupling ordinary rolling stock to rail motor coaches. As regards the heavy oil engine, it has now gained numerous adherents, and the net kilometric expense of light rail motor coaches will show a further appreciable reduction when they have been equipped with an engine of this type. There are already Diesel engines which, in consequence of more complete combustion, give off practically no smoke or smell. Nevertheless, the advantage of the Diesel engine is in part a consequence of the favoured treatment accorded by many States to gas-oil and similar products, compared with the taxes at present imposed upon petrol.

The reporter mentions trials carried out in France, by the Midi Railway Company, with a light rail motor coach, equipped with a three-cylinder, 80 H. P. Diesel engine, giving a speed of up to 80 km. (50 miles) per hour, and consuming 16 litres of gas-oil per 100 km. (5.66 Br. gallons per 100 miles); also trials carried out in Germany with a type of rail motor bus or, more correctly, a combination of two rail motor buses, coupled back to back, the steel-tired wheels of which have been designed specially for the elastic absorption of the vertical shocks at the rail joints, for the lessening of lateral shocks occurring when passing over points, and for the elastic transmission of the power when starting and stopping.

The second category comprises heavy rail motor coaches, with a light weight of up to 50 tons; capacity : about one hundred seats; from 75 to 250 H. P. Expense per kilometre, from 0.970 to 3.981 fr. (1.560 to 6.405 fr. per mile). Average speed, without trailer, 40 km. (25 miles) per hour, maximum speed 65 km. (40.4 miles) per hour.

In the third category the reporter places accumulator rail motor coaches and pneumatic tyred rail motor coaches. The former, in the latest types, have benefited by an appreciable reduction in tare, effected in the Edison type of iron-nickel battery, the weight of which has been brought down from 8.5 to 6 tons.

The latter, designed by the firm of Michelin, had not at the time of preparation of the report passed out of the experimental stage, and it will be necessary to defer the formation of a final opinion in regard to this type of vehicle until it has been in use under normal working conditions for a sufficiently long period. Apart from considerations of comfort and silence, the use of the pneumatic tyred rail motor coach makes it possible to achieve remarkable results from the point of view of starting, braking and high speeds, even on lines which are far from perfect.

The reporter concludes that the critical period through which we are passing has brought the question of rail motor coaches to the fore, and that future trials cannot fail to be particularly instructive from the point of view of their utilisation on railways of local interest, and will perhaps result, little by little, in a profound modification of present methods of working.

As regards present tendencies in the construction of rail motor coaches, the reporter considers that two features stand out clearly :

1. more and more widespread use of heavy oil engines;

2. reduction in weight desired.

3. Report of Messrs. La Valle and Mellini.

In the first part of the report Mr. La Valle remarks that constructional tech-

nique has made scarcely any progress in recent years, except in certain special cases ; nonetheless, the rail motor coaches at present in use are, for the major part of types proved by experience. The results obtained in trials which have been in progress for years past deserve, therefore, to be taken into consideration.

In Italy, there is already a regular service of rail motor coaches with petrol engines and with Diesel engines, with mechanical or electrical transmission, with seating accommodation for from 25 to 56 passengers; they have two driving compartments, and a speed of from 35 to 60 km. (21.7 to 37.3 miles) per hour.

In Algeria, the rail motor coaches have petrol engines and mechanical drive with seating accommodation for from 21 to 54 passengers, one or two driving compartments and a maximum running speed of from 40 to 65 km. (25 to 40.4 miles) per hour. In addition, there are still some old steam motor coaches, with mechanical drive, with seating accommodation for 36 passengers, one driving compartment, and a maximum running speed of 30 km. (18.6 miles) per hour.

In Egypt, the State Railways run some articulated steam motor coaches, with two bodies carried on three bogies. Two driving compartments; maximum speed, 60 km. (37.3 miles) per hour; seating accommodation 109.

In the Argentine, the Buenos Ayres Western Railway uses steam motor coaches with « railway » type of bodywork and mechanical transmission; 41 seats; two driving compartments; maximum speed 65 km. (40.4 miles) per hour without trailer and 52 km. (32.3 miles) per hour with trailer.

The railways of the Portuguese Colony of Mozambique have now under construction Diesel-electric rail motor coaches, with 55 seats and two driving compartments.

As a general rule, all the rail motor coaches give satisfactory service. Maintenance charges are not excessive, and interruptions of service for inspection or repairs are very limited. The average fuel consumption is between 16 and 20 gr. per ton-kilometre (14.77 to 18.46 drams per Engl. ton-mile).

Working with rail motor coaches is, in any case, more advantageous than with steam, so far as concerns staff expenses, cost of fuel and weight per passenger seat.

In the summary to the first part of the report, the reporter emphasizes that, in view of the very high first cost of rail motor coaches, the majority of railway companies have confined themselves to making trials with a single unit, retaining in service the whole of the steam traction organisation. The lack of more general use of rail motor coaches has not favoured technical improvement or a reduction in the cost of these vehicles. This situation is becoming more and more serious as a result of the tendency of most countries practically to prohibit the entry of foreign manufactures by the imposition of high customs duties, making it necessary to restrict experiments, so far as rail motor coaches are concerned, to the material available in the country itself.

The conclusion raises the two following points :

1. Above 150 H. P., the advantage lies with rail motor coaches with Diesel-electric engines;

2. If real advantage is to be derived from the use of rail motor coaches, their use must be extended; they must be employed on appropriate services, and they must completely replace the present steam train services.

* * *

In the second part of the report, the reporter first of all summarises the re-

plies received from the various railway companies, showing a certain preference for the adoption of petrol rail motor coaches (and similar systems) on suburban lines and on light railways in general; the replies appear, particularly, to confirm that the most effective remedy for the plight of those railways whose already diminished traffic is threathened by the present crisis and by road competition is to be found in the formula : *light, fast and economical trains.* The adoption of a light type of train, consisting either of the motor coach alone, or of the motor coach and a trailer, with a single driver and a single conductor, affords the maximum elasticity of working and facilitates greater frequency of trains and of stops. Further, the light train permits of rapid acceleration on starting, quick pulling up on arrival at stations, higher speeds on short runs, the greatest possible reduction in working expenses and the highest degree of utilisation of seating capacity.

The adoption of rail motor coaches with either petrol or heavy-oil engines for the working of railways whose traffic is small has, therefore, much to recommend it, but it can only be considered as part of the much vaster question of putting the light railways in a position to satisfy the ever increasing exigencies of passengers, to survive the present period of acute crisis, to stand up to road competition and, above all, to recapture public favour. It is essential to modernise, to simplify and to transform existing systems of working, with a view to economy and progress, by means which may sometimes be daring innovations.

The reporter arrives at a series of conclusions derived directly from the observations and considerations here summarised and which, with certain modifications and additions suggested by the conclusions of the other reporters, afford a basis for the general conclusions to be submitted for the consideration of the Congress, for, as pointed out in the first part of this report, the opinions and observations of the reporters are fortunately remarkably uniform.

Summary.

1. The rail motor coach, with either a spark or compression-ignition engine, must be considered as one of the systems of traction which meet the requirements of light railways with small traffic, particularly in this critical time which, more than ever, makes economic working a matter of vital importance for all railways. Under special conditions of working, accumulator and steam motor coaches may be considered as an equally useful system of traction.

2. Present tendencies in the construction of rail motor coaches point to the increasing uilisation of heavy-oil engines and to the use of more powerful vehicles, which seems to indicate the necessity of the adoption of electrical transmission. Above 150 H. P., rail motor coaches with Diesel-electric engines are to be advocated.

3. Rail motor coaches should apparently possess the following characteristics :

a) a high running speed, at least of 50 km. (31 miles) per hour;

b) quick acceleration, permitting of equally high commercial speeds;

c) light weight in relation to the seating capacity;

d) a carrying capacity slightly in excess of normal traffic requirements;

f) two driving compartments, or one only, but in the latter case so situated as to permit of driving in both directions.

e) sufficient engine power to haul a second vehicle. This characteristic en-

tails the necessity of fitting standard types of coupling;

4. If real advantage is to be derived from the use of rail motor coaches, there must be a more extensive use of these vehicles and their substitution for the present steam motor coach services must be as complete as possible. This transformation of the system of traction must be accompanied by the necessary modernisation of installations and simplification of working with a view to satisfying the ever increasing exigencies of the public, in particular for fast and frequent trains and moderate fares.

September 1932.

MONTHLY BULLETIN

OF THE

INTERNATIONAL RAILWAY CONGRESS ASSOCIATION

(ENGLISH EDITION)

PUBLISHING and EDITORIAL OFFICES: 74, RUE DU PROGRÈS, BRUSSELS.

Yearly prepaid subscription { **Belgium . . . . . 70 Belgas** / **Other countries . . 75 Belgas** } including postage

Price of this single copy: 8 Belgas (not including postage).

(1 Belga = 5 Belgian francs.)

Subscriptions and orders for single copies (January 1931 and later editions) to be addressed to the General Secretary, International Railway Congress Association, 74, rue du Progrès, Brussels (Belgium).

Orders for copies previous to January 1931 should be addressed to Messrs. Weissenbruch & Co. Ltd., Printers, 49, rue du Poinçon, Brussels.

Advertisements: All communications should be addressed to the Association, **74, rue du Progrès, Brussels.**

CONTENTS OF THE NUMBER FOR FEBRUARY 1933.

CONTENTS.	Page.
I. **Competition or joint working of railways and roadways** in France, by Mr. GILLES-CARDIN	169
II. **Railway traction**	178
III. New procedure for **setting locomotive frames and crosshead guides,** by Herr HILTGEN	191
IV. New method of **automatically locating vertical defects in permanent way,** by C. A. CARDEW	198
V. **Relation of back pressure to locomotive performance,** by G. W. ARMSTRONG.	209
VI. **Aerodynamical experiments on the exterior form to be given rail motor cars,** by Mr. LEBOUCHER	219
VII. The **ventilation of London Tubes**	234
VIII. CURRENT PRACTICE:	
Buffet car for the Leeds-Newcastle service, London and North Eastern Railway.	239
IX. MISCELLANEOUS INFORMATION:	
1. **Fractures in railroad tires**	242
2. **Travelling sub-stations with mercury rectifiers,** Italian State Railways. .	245

CONTENTS (*continued*). Page.

X. NEW BOOKS AND PUBLICATIONS :

L'**Egypte et ses Chemins de fer** (Egypt and its Railways), by Lionel WIENER. 248

Die **Selbstkosten der Verkehrsbetriebe bei schankendem Beschäftigungsgrad**. — Eine betriebswissenschaftliche Studie (The influence of traffic variations upon the cost of operating transport services. — A study of scientific operating), by Dr. F. KUTTNER 249

Hoyer-Kreuter Technologisches Worterbuch — **Hoyer-Kreuter Technological Dictionary** — Dictionnaire technologique Hoyer-Kreuter (Sixth edition). . 250

Ribeiro's **train-rating diagrams**, by G. RIBEIRO and W. HULME 251

Elementi di Calcolo delle **Funivie per servizio pubblico** (Elements entering into the calculation of **aerial railways for public transport** services, by A. MAFFEZZOLI 251

XI. Monthly bibliography of Railways 15

LIBRARY

OF THE

Permanent Commission of the International Railway Congress Association.

READING ROOM : **74, rue du Progrès, Brussels.**

Works in connection with railway matters which are presented to the Permanent Commission are mentioned in the « Bulletin ». They are filed and placed in the library. If the Executive Committee deems it advisable they are made the subject of a special notice. Books and publications placed in the reading room may be consulted by any person in possession of an introduction delivered by a member of the Association. Books, etc., may not be taken away except by special permission of the Executive Committee.

The Permanent Commission of the Association is not responsible for the opinions expressed in the articles published in the Bulletin.

All original articles and papers published in the BULLETIN are copyright, except with the consent of the Authors and the Committee.

Editions in **French** and in **German** are also published.